Notice No. 11

Rules and Regulations for the Classification of Offshore Units, July 2014

The status of this Rule set is amended as shown and is now to be read in conjunction with this and prior Notices. Any corrigenda included in the Notice are effective immediately.

Issue date: June 2015

Amendments to	Effective date
Part 11, Chapter 1, Sections 1.2 & LR 1.6	1 July 2015
Part 11, Chapter 3, Sections 3.3, 3.4 & 3.5	1 July 2015
Part 11, Chapter 4, Sections 4.1, 4.3, 4.6, 4.7, 4.11, 4.14, 4.15, 4.16, 4.18, 4.19, 4.20, 4.21, 4.22, 4.23, 4.24, 4.25 & 4.28	1 July 2015
Part 11, Chapter 5, Sections 5.1, LR 5.14, LR 5.15 & 5.7	1 July 2015
Part 11, Chapter 9, Section 9.4	1 July 2015
Part 11, Chapter 10, Section 10.1	1 July 2015
Part 11, Chapter 11, Sections 11.1, 11.2, 11.3, 11.4, 11.5 & LR 11.7	1 July 2015
Part 11, Chapter 12, Section 12.1	1 July 2015
Part 11, Chapter 16, Section 16.5	1 July 2015
Part 11, Chapter 20 (New)	1 July 2015

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Part 11, Chapter 1

General

Effective date 1 July 2015

1.2 Definitions

1.2.22 **Hazardous area** is an area in which an explosive gas atmosphere is, or may be expected to be present, in quantities that require special precautions for the construction, installation and use of electrical equipment. *See* Pt 7, Ch 2, Sections 1 and 2 and IEC 60092-502 *Electrical installations in ships - Part 502: Tankers – Special features* for the complete definition of hazardous areas including Classification of Hazardous Areas. When a gas atmosphere is present the following hazards may also be present: toxicity, asphyxiation, corrosiveness, reactivity and low temperature; these hazards shall also be taken into account and additional precautions for the ventilation of spaces and protection of the crew will need to be considered.

LR 1.6 Information and plans

LR 1.6.1 In addition to the plans required by the relevant Parts of these Rules, the following information and plans are to be submitted, where applicable:

- Full particulars of the intended cargo, or cargoes, including maximum vapour pressures, minimum and (where necessary) maximum liquid temperature and other relevant design conditions.
- General arrangement showing location of cargo tanks and the relative location of oil fuel, water ballast and other tanks.
- Openings in main deck.
- Location of void spaces and dangerous zones: openings and access arrangements.
- Details of hull structure in way of cargo tanks, including support arrangements for tanks and associated pipes and fittings, deck sealing arrangements, etc.
- Distribution of quality and grade of steel, supported by calculations of the determined hull steel temperature. The steel grade and temperature in regions where cold spots are likely to occur (e.g., pump supports and where pipes pass through the deck) are also to be indicated.
- Scantlings, materials, and arrangements of the cargo containment system, including primary and (where fitted) secondary barriers, keying and support arrangements, and attachments of fittings, piping, etc.
- Ladders, suction supports and towers inside cargo tanks (arrangements, materials and loadings).
- Tank dome plans.
- End coamings around dome.
- Particulars of filling, discharging, venting, relieving and inerting arrangements.
- Details of test procedures.
- Temperature control arrangements.
- Such information and data as may be required to enable analysis of the hull and containment system structure to be carried out by direct calculation methods.
- Details of personnel protection equipment to be included on the safety plan as applicable to the ship unit.
- Assumptions and details of direct calculations procedures used in the structural analysis of the hull.
- Where horizontal and vertical girders are used to support the bulkhead, the bulkhead scantlings may be determined using direct calculation procedures. The assumptions made and the calculations are to be submitted.

Additional requirements for information and plans may be found in the appropriate Chapters of this Part.

LR 1.6.2 The following plans and particulars for Type C independent tanks are to be submitted for approval before construction is commenced:

- Nature of cargoes, together with maximum vapour pressures and minimum liquid temperature for which the pressure vessels are to be approved, and proposed hydraulic test pressure.
- Particulars of materials proposed for the construction of the vessels.
- ~~Particulars of refrigeration equipment.~~
- General arrangement plan showing location of pressure vessels in the ship unit.
- Plans of pressure vessels showing attachments, openings, dimensions, details of welded joints and particulars of proposed stress relief heat treatment.
- Plans of seating, securing arrangements and deck sealing arrangements.
- Plans showing arrangement of mountings, level gauges and number, type and size of safety valves.
- Details of the arrangements proposed to ensure that the tank or cargo temperature cannot be lowered below the minimum design temperature as defined in 4.1.3.
- Plans showing filling, discharging, venting and inerting pipe arrangements, together with particulars of the intended cargo, maximum vapour pressure and minimum liquid temperature.
- Details of calculations and/or model tests are required for the assessment of the tank boundaries with partial filling of tanks.
- Allowable stresses of any materials not covered by Chapter 6 required by 4.18.1.5.
- Details verifying compliance with the periodical examination of the secondary barrier required by 4.6.2.4 if applicable.
- Details of the heating system of the hull structure required by 4.19.1.5 if fitted.
- Specification and plans of the containment system are to be submitted for approval. Plans are to include:
  - Details of insulation material and, if used, any adhesive, sealers, coatings or similar products.
  - Details of insulation arrangement.
  - Internal bearers or steelwork.
  - Tank supports, chocks, etc.
  - Hatch trunks.
  - Attachment and support of insulation and linings.
  - Data and information to enable a heat leakage calculation to be carried out to assess the capacity of the arrangements provided to deal with boil-off, including:
  - Thermal conductivity of insulation between upper ambient and design temperatures.
  - ~~Details of reliquefaction/refrigeration plant duty or maximum allowable boil-off rate for each cargo.~~
- The proposed procedure for fabrication, storage, handling, erection, quality control and control against harmful exposure to sunlight of insulation materials.
- Calculations and/or analysis of strength of insulation where it is subjected to high mechanical or thermal loads.
- Fatigue and crack propagation properties for insulation in membrane systems are also to be submitted.
- Specifications of the containment system items are to include both those applicable to initial approval of the material, and those applicable to subsequent delivery of batches of material.
- ~~Plans illustrating the means of protection for the steelwork of the ship unit, e.g., drip trays, cladding, etc., at loading manifolds: deck tanks, cargo handling system, etc.~~

Additional requirements for information and plans may be found in the appropriate Chapters of this Part.

LR 1.6.3 The following plans and particulars for Membrane tanks are to be submitted for approval before construction is commenced:

- Recovery Duration (as specified in LR 4.1.1), nature of cargoes, together with maximum vapour pressures and minimum liquid temperature for which the membrane tanks are to be approved.
- Particulars of materials proposed for the construction of the tanks.
- General arrangement plan showing location of membrane tanks in the ship unit and location of relieving devices per tank.
- Plans of membrane tanks showing general construction arrangements and installation methodology.
- Plans of membrane tanks showing insulation panels distribution, levelling and fastening arrangements.
- Plans of membrane tanks showing openings, dimensions, and details of welded joints.
- Details of the arrangements proposed to ensure that the tank or cargo temperature cannot be lowered below the minimum design temperature as defined in 4.1.3.
- Plans showing filling, discharging, venting, inerting and draining pipe arrangements, together with particulars of the intended cargo, maximum vapour pressure and minimum liquid temperature.
- Details of calculations and/or model tests, when partial filling of tanks are considered, for the assessment of the containment system integrity.
- Allowable stresses of any materials not covered by Chapter 6 required by 4.18.1.5.
- Details verifying compliance with the periodical examination or NDT of the secondary barrier required for approval by 4.6.2.4 if applicable.
- Details of the heating system of the hull structure required by 4.19.1.5 if fitted.
- Specification and plans for all the containment system components are to be submitted for approval. These plans and specifications are to include:
  - Details of insulation material and, if used, any adhesive, sealers, fillers, coatings or similar products. Properties documented to include:
    - density,
    - elastic modulus and Poisson's ratio,

- porosity,
- thixotropic nature,
- thermal conductivity,
- thermal expansion/contraction,
- and any thermal variation of material properties required by the system.

- Details of insulation arrangement, including installation, welding, gluing, joining procedures and other mechanical means not already covered.
- Inner hull anchoring flat bars, including definition of surface and levelling quality required.
- Repair procedures defining imperfection, defects, their allowable limits and subsequent repair processes.
- Document showing clear system for identification and traceability of parts and components in order to easily act on failure trends.
- Attachment and support of insulation and linings including bearing limitations in terms of movement, discontinuous connections, angles, steps and spaces.
- Data and information to enable a heat leakage calculation to be carried out to assess the capacity of the arrangements provided to deal with boil-off, including:
  - Thermal conductivity of insulation between upper ambient and design temperatures.
- Details of the means of on-site inspection and repair procedures and details of any loads which will be imparted upon the membranes as a result of the on-site inspection and repair procedures. These details need to include:
  - The method to be used.
  - Any loads which will be imparted upon the membranes.
  - The acceptance criteria.
  - The weather conditions for which it will be permitted to undertake inspection and repair operations.
  - The form of record to be made.

  Entry into tank space for inspection purposes should be avoided where possible.

  The testing and inspection should be commensurate with assumptions made in the design of the containment system, *see* 4.18.2.6.
- Details of on-site inspection to be carried out following an exceptional severe event (of similar magnitude of a 10 000 years return period event as per LR 4.3.3).
- Details of proposal for tank preservation in case the intervening period between the cargo tank completion and the first cool down is expected to be significant.

- The proposed procedure for fabrication, storage, handling, erection, quality control and control against harmful exposure to sunlight of insulation materials.
- Testing results and/or calculations and/or analysis of strength of insulation demonstrating capability to withstand high mechanical and thermal loads.
- Site specific calculations and analyses to include:
  - Sloshing and liquid motion analyses justifying the proposed filling level ranges.
  - Fatigue and crack propagation and tearing properties of insulation system components.
  - Specifications of the containment system items are to include both those applicable to initial approval of the material, and those applicable to subsequent delivery of batches of material.

Additional requirements for information and plans may be found in the appropriate Chapters of this Part.

Part 11, Chapter 3

Ship Arrangements

Effective date 1 July 2015

3.3 Cargo machinery spaces and turret compartments

3.3.4 Cargo compressors and cargo pumps may be driven by electric motors in an adjacent non-hazardous space separated by a bulkhead or deck if the seal around the bulkhead penetration ensures effective gas-tight segregation of the two spaces. Where these cargo compressors and cargo pumps are located in hazardous areas, they are to comply with Pt 7, Ch 2,5.1.2. ~~Alternatively such equipment may be driven by certified safe electric motors adjacent to them if the electrical installation complies with the requirements of Chapter 10.~~ Alternatively the use of motor compressor and motor pump sets with the complete package certified for use in hazardous areas is acceptable.

3.4 Cargo control rooms

3.4.3 If the cargo control room for ship units carrying flammable cargoes is classified as a hazardous area, sources of ignition shall be excluded and any electrical equipment shall be installed in accordance with Chapter 10 and Pt 7, Ch 2,8.

3.5 Access to spaces in the cargo area

(Part only shown)

3.5.3 Arrangements for hold spaces, void spaces, cargo tanks and other spaces defined as hazardous areas in Chapter 10 and Pt 7, Ch 2,2, shall be such as to allow entry and inspection of any such space by personnel wearing protective clothing and breathing apparatus and shall also allow for the evacuation of injured and/or unconscious personnel.

Part 11, Chapter 4

Cargo Containment

Effective date 1 July 2015

4.1 Definitions

LR 4.1.1 Recovery Duration (RD). When a secondary barrier, or a partial secondary barrier, is required an RD is defined as the time (in days) necessary to make the ship unit safe, secure and ready for repair after a leak through the primary barrier is detected.
In the calculation of the RD, due account shall be taken of liquid evaporation, rate of leakage, access to external facilities such as shuttle tankers, pumping capacity and other relevant factors such as operational situations, human factors, delays due to weather conditions.
The required RD and the associated safety factor shall be advised to LR at the commencement of the project.

4.3 Functional Requirements
(*Part only shown*)

4.3.4 The cargo containment system structural strength shall be assessed against failure modes, including but not limited to plastic deformation, buckling, and fatigue. The specific design conditions that should be considered for the design of each cargo containment system are given in 4.21 to 4.26. There are three main categories of design conditions:

.1 ~~**Ultimate**~~ **On-site operation design conditions** – The cargo containment system structure and its structural components shall withstand loads liable to occur during its construction, testing and anticipated use in service, without loss of structural integrity. The design shall take into account proper combinations of the following loads:

- Internal pressure.
- External pressure.
- Dynamic loads due to the motion of the ship unit.
- Thermal loads.
- Sloshing loads.
- Loads corresponding to deflections of the ship unit.
- Tank and cargo weight with the corresponding reaction in way of supports.
- Insulation weight.
- Loads in way of towers and other attachments.
- Test loads.

The loads are to be calculated at a return period of 100 years.

- ~~10 000 year return period loading (this requirement may be waived where it can be proven that it is not appropriate, on a site-specific basis).~~

The relevant acceptance criteria and allowable stresses are to be in accordance with Section 4.21.3, or Section 4.22.3 or Section 4.23.3 or Section 4.24.5 or Section LR 4.25.1 as appropriate.

.2 **Fatigue design conditions** – The cargo containment system structure and its structural components shall not fail under accumulated cyclic loading.

.3 ~~**Accident design conditions**~~ **Accident design conditions** – The cargo containment system shall provide the indicated response to each of the following accident conditions (accidental or abnormal events), addressed in this Part:

- Collision – the cargo containment system shall be protectively located in accordance with 2.4.1 and withstand the collision loads specified in 4.15.2 without deformation of the supports, or the tank structure in way of the supports, likely to endanger the tank structure.
- Fire – The cargo containment systems shall sustain without rupture the rise in internal pressure specified in 8.4.1 under the fire scenarios envisaged therein.
- Flooded compartment causing buoyancy on tank – The anti-flotation arrangements, for independent tanks, shall sustain the upward force, specified in *4.15.*~~*1*~~*1* and there should be no endangering plastic deformation to the hull.

The relevant acceptance criteria and allowable stresses are to be in accordance with Section LR 4.21.3, or Section LR 4.22.2, or Section LR 4.23.4, or Section LR 4.24.3, or Section LR 4.25.2 as appropriate.

LR 4.3.3 In addition to the loading conditions defined in 4.3.4, a 10 000 year return period design condition is to be considered defined as follows:

10 000 year return period design condition – The cargo containment system integrity and its structural components shall withstand 10 000 year return period loads without loss of containment integrity and without hydrocarbon release. The design shall take into account proper combinations of the following loads:

- Internal pressure.
- External pressure.
- Dynamic loads due to the motion of the ship unit.
- Thermal loads.
- Sloshing loads.
- Loads corresponding to deflections of the ship unit.
- Tank and cargo weight with the corresponding reaction in way of supports.
- Insulation weight.
- Loads in way of towers and other attachments.

Existing paragraph LR 4.3.3 *has been renumbered* LR 4.3.4*.*

4.6 Design of secondary barriers

(*Part only shown*)
4.6.2 The design of the secondary barrier shall be such that:

.1 It is capable of containing any envisaged leakage of liquid cargo for ~~a period of 15 days~~ the RD, as specified in LR 4.1.1, unless different project-specific requirements apply, taking into account the load spectrum referred to in 4.18.2.6. Project-specific requirements are to be submitted for consideration.

4.7 Partial secondary barriers and primary barrier small leak protection system

(*Part only shown*)
4.7.1 Partial secondary barriers as permitted in 4.4.3 shall be used with a small leak protection system and meet all the requirements in *4.6.2*. The small leak protection system shall include means to detect a leak in the primary barrier, provision such as a spray shield to deflect any liquid cargo down into the partial secondary barrier, and means to dispose of the liquid, which may be by natural evaporation.

Part B Design loads

4.11 General – Part B

This Section defines the design loads to be considered with regard to the requirements in 4.16, 4.17 and 4.18. This includes:

- Load categories (permanent, functional, environmental and accidental) and the description of the loads.
- The extent to which these loads ~~should~~ shall be considered depends on the type of tank, and is more fully detailed in the following paragraphs.
- Tanks, together with their supporting structure and other fixtures, that shall be designed taking into account relevant combinations of the loads described below.

4.14 Environmental Loads

4.14.1 **Loads due to ~~ship motion~~ the motions of the ship unit**

The determination of dynamic loads shall take into account the long-term distribution of ~~ship motion~~ the motions of the ship unit in irregular seas, which the ship unit will experience during its operating life. Account may be taken of the reduction in dynamic loads due to heading control.

4.14.1.1 The motions of the ship unit shall include surge, sway, heave, roll, pitch and yaw. The accelerations, derived from site specific wave data and the heading analysis, acting on tanks, shall be estimated at their centre of gravity and include the following components:

- vertical acceleration: motion accelerations of heave, pitch and possibly roll (normal to the base of the ship unit);
- transverse acceleration: motion accelerations of sway, yaw and roll and gravity component of roll;
- longitudinal acceleration: motion accelerations of surge and pitch and gravity component of pitch.

4.14.1.2 Methods to predict accelerations due to ship motion shall be proposed to LR and approved by LR.

4.14.1.3 Guidance formulae for acceleration components are given in 4.27.2.

4.15 Accidental Loads
(*Part only shown*)

4.15.2 **Collision loads**

Where collision is defined by the Owner as a credible accidental load case, the requirements in this section are to be followed in order to assess the chocks and supports of the tanks.
Assessment against collision is to be in accordance with Pt 4, Ch 3,4.16.
All static loads are to be applied. Environmental loads need not be applied. Acceleration resulting from the collision is to be applied to all of the mass of the model including the cargo in the tanks.

4.15.3 **Loss of heading control**
Where stern thrusters or other means of heading control are fitted to weathervaning units then the effect of any single failure of the heading control system on the cargo containment.

4.16 General – Part C

The structural design shall ensure that tanks have an adequate capacity to sustain all relevant loads with an adequate margin of safety. This ~~should~~ shall take into account the possibility of plastic deformation, buckling, fatigue and loss of liquid and gas tightness.

4.16.1 The structural integrity of cargo containment systems can be demonstrated by compliance with 4.21 to 4.26, as appropriate for the cargo containment system type.

4.16.2 The structural integrity of cargo containment system types that are of novel design and differ significantly from those covered by 4.21 to 4.26 shall be demonstrated by compliance with 4.28 to ensure that the overall level of safety provided in this chapter is maintained.

4.18 Design Conditions
(Part only shown)

All relevant failure modes shall be considered in the design for all relevant load scenarios and design conditions. The design conditions are given in the earlier part of this Chapter, and the load scenarios are covered by 4.17.2.

4.18.1 ~~**Ultimate**~~ **On-site operation design condition**
Structural capacity may be determined by testing, or by analysis, taking into account both the elastic and plastic material properties, or by simplified linear elastic analysis.

4.18.1.2 Analysis shall be based on characteristic load values as follows:

Permanent Loads	Expected Values
Functional Loads	Specified Values
Environmental Loads	~~For wave loads; most probable largest load encountered by the ship unit during its operating life.~~ Wave loads are to be calculated at a return period of 100 years.

4.18.1.3 For the purpose of ~~ultimate~~ strength assessment the following material parameters apply:

4.18.2 Fatigue design condition

(Part only shown)
4.18.2.2 ~~Where a fatigue analysis is required, the maximum allowable cumulative fatigue damage ratio is to be less than or equal to 0,5, but is to be no greater than 0,33 for any parts of the supporting structure which are not accessible for inspection during the service life of the unit.~~ The maximum allowable cumulative fatigue damage ratio C_W is to be less than or equal to 0,5, but is to be no greater than 0,33 for any parts of the supporting structure which are not accessible for inspection during the service life of the unit.
~~The fatigue assessment of the cargo containment system is to be verified in accordance with the LR ShipRight FOI Design, Construction and Operation Procedure for Floating Offshore Installations.~~
~~The loading/unloading history is to be consistent with the intended operation of the ship unit. Plastic strain is to be accounted for in the low cycle region. Loading and unloading cycles are to include a complete pressure and thermal cycle.~~
The fatigue damage shall be based on the design life of the ~~tank~~ containment system but not less than ~~10^8 wave encounters~~ 25 years unless agreed otherwise by LR.

4.18.2.3 ~~Where required, the cargo containment system shall be subject to fatigue analysis, considering all fatigue loads and their appropriate combinations for the expected life of the cargo containment system. Consideration shall be given to various filling conditions.~~ The fatigue assessment of the cargo containment system is to be verified in accordance with the ShipRight Procedure for Ship Units.
The loading/unloading history is to be consistent with the intended operation of the ship unit. Plastic strain is to be accounted for in the low cycle region. Loading and unloading cycles are to include a complete pressure and thermal cycle.

4.18.2.6 Where the size of the secondary barrier is reduced, as is provided for in 4.4.3, fracture mechanics analyses of fatigue crack growth shall be carried out for the primary barrier to determine:

- Crack propagation paths in the structure.

- Crack growth rate.
- The time required for a crack to propagate to cause a leakage from the tank.
- The size and shape of through-thickness cracks.
- The time required for detectable cracks to reach a critical state.

The fracture mechanics are in general based on crack growth data taken as a mean value plus two standard deviations of the test data.

4.18.2.6.1 In analysing crack propagation the largest initial crack or equivalent defect not detectable by the inspection method applied shall be assumed, taking into account the allowable non-destructive testing and visual inspection criterion as applicable.

4.18.2.6.2 For the crack propagation analysis under the condition specified in 4.18.2.7, the simplified load distribution and sequence over ~~a period of 15 days~~ the RD, as specified in LR4.1.1, may be used, unless different project-specific requirements apply. Project-specific requirements are to be submitted for consideration. Such distributions may be obtained as indicated in Fig. 4.1. Load distribution and sequence for longer periods, such as in 4.18.2.8 and 4.18.2.9 shall be approved by LR.

4.18.2.6.3 The arrangements shall comply with 4.18.2.7 to 4.18.2.9 as applicable.

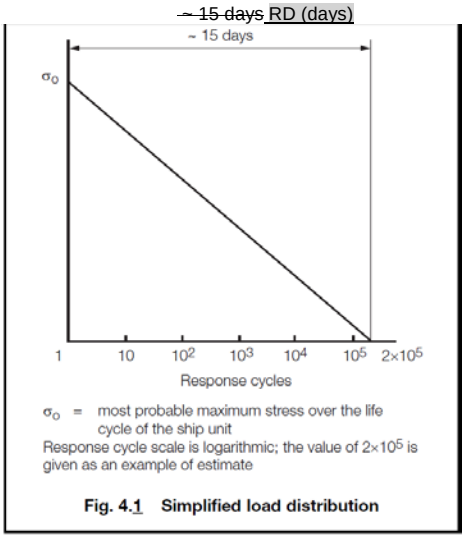

Fig. 4.1 Simplified load distribution

4.18.2.7 For failures that can be reliably detected by means of leakage detection;
• *C*w shall be less than or equal to 0,5.
• The predicted remaining failure development time, from the point of detection of leakage until reaching a critical state, shall not be less than ~~15 days~~ the RD, as specified in LR 4.1.1, unless different project-specific requirements apply.
Project-specific requirements are to be submitted for consideration.

4.19 Materials

4.19.1.1
(*Part only shown*)

.7 No credit shall be given for any means of heating, except as described in 4.19.1.5 and provided the heating arrangements are in compliance with 4.19.1.6.

~~**LR 4.19.5** Where the insulation is located on or immediately adjacent to the open deck, or is in an interbarrier or hold space not kept inerted in accordance with 9.2.1, it is to have suitable fire resistance properties. If the insulation is located in an inerted atmosphere and is separated from the open deck by a void space or ballast tank, then insulation having fire resisting properties is not required.~~
~~In addition, all insulation is to be covered with a covering having low flame spread characteristics.~~
~~An efficient vapour barrier (seal) is to be provided on the outer surface of the insulation. The vapour barrier is to be of an approved type.~~

LR 4.19.~~6~~5 Particular attention is to be paid to the cleaning of the steelwork prior to the application of the insulation. Where insulation is to be foamed or sprayed *in situ*, the minimum steelwork temperature at the time of application is to be indicated in the specification in addition to environmental conditions.

4.20 Construction processes
(Part only shown)

4.20.3.4 The Administration may require that, for ship units fitted with novel Type B independent tanks or tanks designed according to 4.28, at least one prototype tank and its supporting structures shall be instrumented with strain gauges or other suitable

equipment to confirm stress levels. Similar instrumentation may be required for Type C independent tanks, depending on their configuration and on the arrangement of their supports and attachments.

LR 4.20.6 Repair Procedures shall define imperfection and defects and their allowable limits, identification of failure type and subsequent repair processes.
Repairs shall be of a quality standard as defined in 4.20.
Records of the performance of the repaired components and equipment, essential to verify the design parameters, shall be maintained and be available.

4.21 Type A independent tanks

4.21.3 ~~**Ultimate**~~ **On-site operation design condition**

LR 4.21.3 10 000 year return period design condition

The effects on the containment system of the 10 000 year return period wave loading are to be considered, as follows:
- Dynamic cargo pressure loading.
- Greatest sloshing pressures distribution.

Calculations and analyses are to be performed to show that there would be no gross failure of the cargo tanks, and no failure of the tank support system or pipe connections in this event.

4.22 Type B independent tanks
(Part only shown)

4.22.1.2 If the cargo temperature at atmospheric pressure is below –10°C, a partial secondary barrier with a small leak protection system is required as defined in ~~4.4~~ 4.5. The small leak protection system shall be designed according to 4.7.

4.22.3 ~~**Ultimate**~~ **On-site operation design condition**

4.22.3.1 **Plastic deformation**

Allowable stresses for Type B independent tanks are to be in accordance with 4.22.3.1.1 and 2.22.3.1.2 as applicable.

4.22.3.1.1 For Type B independent tanks, primarily constructed of bodies of revolution, the allowable stresses shall not exceed:
$\sigma m \leq f$
$\sigma L \leq 1{,}5f$
$\sigma b \leq 1{,}5F$
$\sigma L + \sigma b \leq 1{,}5F$
$\sigma m + \sigma b \leq 1{,}5F$
$\sigma m + \sigma b + \sigma g \leq 3{,}0F$
$\sigma L + \sigma b + \sigma g \leq 3{,}0F$
where:
σm = equivalent primary general membrane stress
σL = equivalent primary local membrane stress
σb = equivalent primary bending stress
σg = equivalent secondary stress
f = the lesser of (Rm/A) or (Re/B)
F = the lesser of (Rm/C) or (Re/D)
with Rm and Re as defined in 4.18.1.3. With regard to the stresses σm, σL and σb *see also* the definition of stress categories in *4.27.3*. The values A, B, C and D shall have at least the minimum values shown in Table 4.22.1.

4.22.3.1.2 For Type B independent tanks, primarily constructed of plane surfaces, the allowable ~~stress levels~~ membrane equivalent stresses applied for finite element analysis will be specially considered:

4.22.3.1.3 The thickness of the skin plate and the size of the stiffener shall not be less than those required for Type A independent tanks.

LR 4.22.2 10 000 year return period design condition

The effects on the containment system of the 10 000 year return period wave loading are to be considered, as follows:
- Dynamic cargo pressure loading.
- Greatest sloshing pressures distribution.

Calculations and analysis are to be performed to show that there would be no gross failure of the cargo tanks, and no failure of the tank support system or pipe connections in this event.

4.23 Type C independent tanks
(Part only shown)

4.23.2.5 Stress analysis in respect of static and dynamic loads shall be performed as follows:

.1 Pressure vessel scantlings shall be determined in accordance with 4.23.2.1 to 4.23.2.4 and 4.23.3.

4.23.3 ~~**Ultimate**~~ **On-site operation design condition**

LR 4.23.4 **10 000 year return period design condition**

The effects on the containment system of the 10 000 year return period wave loading are to be considered, as follows:

- Dynamic cargo pressure loading.
- Greatest sloshing pressures distribution.

Calculations and analysis are to be performed to show that there would be no failure of, or leakage from, the pressure vessels, and no failure of the tank support system or pipe connections in this event.

4.24 Membrane tanks

4.24.4 **Structural analyses**

4.24.4.1 Structural analyses and/or testing for the purpose of determining the ~~ultimate~~ strength and fatigue assessments of the cargo containment and associated structures, e.g., structures as defined in 4.9 shall be performed. The structural analysis shall provide the data required to assess each failure mode that has been identified as critical for the cargo containment system.

4.24.5 ~~**Ultimate**~~ **On-site operation design condition**

LR 4.24.3 **10 000 year return period design condition**

The effects on the containment system of the 10 000 year return period wave loading are to be considered, as follows:

- Hull girder interaction loading.
- Greatest sloshing pressures distribution.

Calculations and analyses are to be performed to show that either the primary barrier or the secondary barrier should be expected to remain liquid tight and firmly fastened down in this event.

LR 4.24.4 Selected details of the containment system are to be investigated by fatigue analysis, which should take into account interactions with the vessel-supporting structure of the ship unit, including local, transverse and longitudinal hull girder effects, also pressure loading from the cargo and from ballast acting on the supporting structure. The number of cycles of full and partial loading and unloading are to be consistent with the operational philosophy of the unit. For investigation of the fatigue damage sustained by the secondary barrier following failure of the primary barrier, a simplified load distribution over ~~a period of 15 days~~ the RD, as specified in LR 4.1.1, may be used, unless different project-specific requirements apply, as described in 4.6.2.1. Project-specific requirements are to be submitted for consideration.

4.25 Integral tanks

(Part only shown)

LR 4.25.1 **On-site operation design condition**

Integral tanks are to be designed and constructed in accordance with the requirements for cargo tanks in Part 10, using the actual cargo density and additional vapour pressure.

~~*4.25.3* **Ultimate design condition**~~

LR 4.25.2 **10 000 year return period design condition**

The effects of 10 000 year return period wave loading on the containment system are to be considered. This is to include:

- Hull girder loading.
- Dynamic cargo pressure loading.
- Greatest sloshing pressures distribution.

Calculations and analyses are to be performed to show that there would be no gross failure of the cargo tanks in this event.

4.25.4~~3~~ **Accident design condition**

4.25.4~~3~~.1 The tanks and the tank supports shall be designed for the accidental loads specified in 4.3.4.3 and 4.15, as relevant.

4.25.5~~4~~ **Testing**

All integral tanks shall be hydrostatically or hydro-pneumatically tested. The test shall be performed so that the stresses approximate, as far as practicable, to the design stresses and that the pressure at the top of the tank corresponds at least to the MARVS.

Part G Cargo containment systems of novel configuration

4.28 Design for novel concepts

4.28.1 Cargo containment systems that are of a novel configuration that cannot be designed using sections 4.21 to 4.26 shall be designed using this section and Parts A and B of this chapter, and also Parts C and D, as applicable.
The procedure and relevant design parameters will be specially considered.

Part 11, Chapter 5

Process Pressure Vessels and Liquids, Vapour and Pressure Piping Systems and Offshore Arrangements

Effective date 1 July 2015

5.1 General
(*Part only shown*)

5.1.3 Process pressure vessels include but are not limited to: surge ~~tanks~~ vessels, heat exchangers and accumulators that store or treat liquid or vapour cargo.

LR 5.14 Cryogenic liquefied gas spill control

LR 5.14.4 Documents and plans

LR 5.14.4.9 During the risk assessment each identified accident/casualty scenario shall where necessary be graded with respects to severity of consequence and likelihood of occurrence. This grading shall provide a risk ranking that can be related to an appropriate risk matrix. The risk matrix shall distinguish risk into a series of groupings;

- unacceptable or intolerable;
- tolerable if ALARP; and
- acceptable, tolerable or negligible.

The risk matrix may be adapted from the IMO Guidelines on Formal Safety Assessment (FSA) – MSC/Circ.1023 MEPC/Cic.392 and the target individual risk levels for crew members given by the FSA for LNG-Carriers - MSC 72/16.

LR 5.14.7 Blowdown/depressurisation

LR 5.14.7.1 ~~The design of the liquefied gas process piping system is to allow the safe depressurisation or blowing down of the unaffected and isolated sections of the process system either to safely flare or drain inventory back to cargo tanks.~~ Blowdown is defined as:
The depressurisation of a system, part of a system and its equipment to allow the safe disposal of both vapour and liquid discharged from blowdown valves. Depressurisation is used to mitigate the consequences of a pipeline or vessel leak by reducing the leakage rate and/or inventory within the pipe or vessel prior to a potential failure.

LR 5.14.7.2 ~~Where a liquid blowdown system is provided in the process plant, the design and installation are to make adequate provision for the effects of back pressure in the system and vapour flash off when the pressures of liquids in the blowdown system are reduced~~. A depressurisation and blowdown system shall be provided for depressurising the high pressure liquid and gas pumps, vessels and pipework. The recommendations and guidelines given in standards such as ISO 23251 due to it being applicable to liquefied natural gas (LNG) and oil and gas production facilities shall be used for establishing a basis of design.

LR 5.14.7.3 ~~Substances which will react with each other are to be provided with separate systems.~~ Where a liquid depressurisation system is provided, adequate provision shall be made in the design and installation for the effects of back pressure in the system and vapour flash-off when the pressures of liquids in the blowdown system are reduced.

LR 5.14.7.4 Manual and automatic activation of the depressurisation system shall be provided.

LR 5.14.7.5 Manual activation of the depressurisation system shall be possible from the process control station, local to the vessel or system being protected. Activation from other locations, as determined by the type, number, location and position of the process systems and equipment, shall also be possible. The designer of the system should recognise that a manual control may not be accessible during a fire.

LR 5.14.7.6 Automatic activation shall be part of the emergency shutdown arrangements.

LR 5.14.7.7 The maximum potential system release inventory due to depressurisation should be calculated for both individual systems and the maximum common-mode event. Consideration can be given to project specific philosophies such as staged blowdown. The disposal system is to be sized to deal with the maximum common-mode event inventory and resultant flash gas. To prevent exceeding the flare system capacity, the use of a liquid blowdown collection drum, knockout drum or liquid return to the storage tanks where possible, shall be proposed.

LR 5.14.7.8 Substances which will react with each other are to be provided with separate systems.

LR 5.14.8 Limiting ~~cryogenic~~ liquid gas spills and releases

LR 5.14.8.1 ~~Bunds, drip trays and spray guards resistant to cryogenic temperatures must be provided at manifolds and flanged connections in the liquefied gas system.~~ Suitable arrangements are to be provided to reduce the chance of unintentional releases of liquid gas and mitigate the effects of such releases.

LR 5.14.8.2 ~~Liquefied gas process equipment and associated piping system are to be located within a bunded area with provision for the drainage of rain or fire water.~~ Spray shields shall be fitted in way of all demountable joints, such as the terminal manifolds where leakage may occur at valves and pipe joints. Propriety shields or clamps, surrounding each demountable flange, fabricated from a material suitable for the pipework's contents, may be proposed.

LR 5.14.8.3 ~~The liquefied gas process piping and associated equipment arrangement is to not allow the possibility for liquefied gas spills or leaks to accumulate under any storage vessels or equipment~~. Where open drive pumps are installed, splash guards and drip trays around and below the pump shaft seal shall be provided. Guards and drip trays shall be constructed of a suitable material as per the requirements of Chapter 6, Section 6.4.

LR 5.14.8.4 ~~The bunding is to consist of a raised impermeable material, able to withstand the static pressure and temperature of the cryogenic liquid spilled, around the perimeter of an impounding area.~~ Where the inventory of liquid gas necessitates, the use of impoundments shall be proposed. In process areas where there are numerous valves, fittings, pumps and flanges a common impoundment, covering the area of possible liquid release, may be required.

LR 5.14.8.5 ~~The capacity of the bunded area shall be greater than the amount of liquid which would be spilled by breakage of the pipe with the highest leakage rate for the time necessary for detection and for interruption of flow~~. The capacity of the drip trays/impoundment shall be based on an assessment of the largest credible containable spill. For guidance, if means are provided to automatically detect liquid releases, this capacity may be the contents of the pipework between isolating valves. For discharge facilities this capacity may be outboard section of one transfer arm, or one cargo hose, plus the volume of liquid between one of the unit's manifold valves and the highest point in the crossover.

LR 5.14.9 Protection of steelwork against brittle fracture

LR 5.14.9.1 Requirements are to be provided to minimize the risks associated with the uncontrolled release of low temperature liquids. In locations where a release of low temperature liquid could occur, suitable mitigation methods are to be provided. The techniques selected need to consider; the inventory volume, maximum liquid pressure, minimum liquid temperature and the direction of possible leakage.

LR 5.14.9.2 Where drip trays and impoundment are used the material shall be selected to withstand exposure at the saturation temperature of the released liquid. The boundaries of the drip tray and impoundments are to be such to remain effective at the angles of inclination stated in Part 5, Chapter 1, Table 1.2.1.

LR 5.14.9.3 Drip trays and impoundments containing low temperature liquid are not to adversely affect supporting or adjacent steelwork. The fitting of thermal breaks to drip tray supports and insulation between impoundments and supporting steelwork structure is to be considered.

LR 5.14.9.4 Where it is established that the liquid release may be substantial, the ability to drain drip trays and impoundments to be drained to an appropriate location or collection vessel is to be provided.

LR 5.14.9.5 Unless the material has been selected accordingly, a water distribution system shall be fitted in way of the hull under the discharge connections to provide a low-pressure water curtain for additional protection of the hull steel and the side structure. This system is in addition to the requirements of 11.3.1.4, and shall be operated when discharging is in progress.

LR 5.14.9.6 Personnel access ways, escape routes and refuge areas are to be protected against the possibility of uncontrolled release of low temperature liquids.

LR 5.15 Liquefied gas transfer systems – General requirements

LR 5.15.1 Application

LR 5.15.1.2 ~~The extent of liquefied gas transfer system and facilities are subject to agreement between the designer and Owner/Operator. The classification approval process will involve assessment of the safety of the proposed facilities from concept to through life operability and de-commissioning. Liquefied gas transfer operations are extremely hazardous and those involved in the development of such systems need to address safety issues to minimise the risks to the offshore unit, personnel and the environment. Operational procedures and regular crew training are essential to minimise these risks and reduce hazards to as low as reasonably practicable. Attention is drawn to the following guidance documents and standards:~~
~~• Ship to ship transfer guide (Liquefied Gases) 2nd Edition, published by OCIMF/SIGTTO.~~
~~• ICS/OCIMF 'Ship to ship Transfer Guide (petroleum) 4th edition'.~~
~~• OCIMF 'Mooring Equipment Guideline 3'.~~
~~• EN 1474 'Installation and Testing for Liquefied Natural Gas – Design and Testing of Marine Transfer Systems'.~~

LR 5.15.1.2 The *Rules and Regulations for the Classification of Offshore Units* are applicable to liquefied gas floating production units and liquefied gas floating storage ship and barge type units. Unless a dedicated or novel offloading design is

proposed, the gas carriers used for transferring liquefied gas will have been designed in accordance with the IGC Code, Classification Rules and industry guidance. Thus the means provided for discharging liquid gas are to be in compliance with standard marine practices with regard to Class, layout, loadings and support. Consideration is to be given to guidance provided in the SIGTTO publication titled; Manifold Recommendations for Liquefied Gas Carriers.

LR 5.15.1.2.1 Where the method of offloading is of a novel design, such as a tandem over the bow arrangement, the design of the liquefied gas transfer system is to be shown to achieve the same level of safety and integrity as a standard marine system.

LR 5.15.1.2.2 Where a traditional loading arm offloading arrangement is installed consideration shall be given to the effects of environmental factors such as unit motions and accelerations. Loading arm support columns are to be designed in accordance with the requirements of Part 3, Chapter 7, Section 2.7 of these Rules.

LR 5.15.1.2.3 Suitable facilities are to be installed to allow periodic maintenance such as the change out of offloading swivels, bearings and PERC overhaul whilst the unit remains on station.

LR 5.15.1.2.4 Each type and design of offloading arrangement is to have the ability to be locked in a safe storage position in the event of extreme storms.

LR 5.15.3 Design and operating principles

LR 5.15.3.1 ~~Liquefied gas transfer systems are to be designed in accordance with user defined operating and performance criteria taking account of the offshore unit type and service operating envelope~~. Where the operation of the unit is to be at a specific location consideration will be given to the metocean data applicable to that area rather than the global ambient conditions stated in Part 6, Chapter 2, Section 1.9 of these Rules. Safety systems and essential auxiliary machinery are to operate at the angles of inclination given in Part 5, Chapter 1, Table 1.2.1 of these Rules. Any proposal to deviate from these angles of inclination will be specially considered taking into account the type, size and service conditions of the unit.

LR 5.15.3.2 Unless agreed otherwise, the unit is to be capable of operation within specified operating conditions that include maximum sea states, wind conditions and those identified in the Rules for Offshore Units. Where the metocean data applicable to the area where the unit will be stationed provides lesser environmental conditions, consistent with the expected usage, these may be accepted. The following information is to be submitted where relevant to the offloading unit type and its design. Design environmental criteria applicable to each mode, including wind speed, wave height and period, or sea state/wave energy spectra (as appropriate), water depth, tide and surge, current speed, minimum air temperature, ice and snow loads. Consideration is to be given to the content of Part 3, Chapter 10, Section 3.3 of these Rules.

~~**LR 5.15.3.6** Liquefied gas transfer systems are to be designed to minimise the risks to the hull structure, personnel and the environment. The risks involved in carrying out identified hazardous activities are to be as low as reasonably practicable.~~

LR 5.15.4 Acceptance criteria

LR 5.15.4.1 General. ~~The acceptance process will validate conformity of liquefied gas transfer system to the provisions of classification for systems within the vessel type by assessing such systems for compliance with Lloyd's Register's (hereinafter referred to as 'LR') Rules for Offshore Units, and specified standards and codes.~~ These Rules have been developed to achieve a standard of design and construction quality that ensures an acceptable level of safety and assurance of integrity of the installation.

LR 5.15.4.1.1 Deviations from the Rules, using risk assessment as a method for justifying Class, must therefore demonstrate that such changes to the design and construction of an installation or its parts do not result in an unacceptable level of safety or integrity of the installation.

LR 5.15.4.1.2 LR will require the Owner/Operator to develop risk acceptance criteria to be achieved by the design and maintained in service, to ensure the safety and integrity of the installation in line with the spirit and intent of Lloyd's Register's Rules.

LR 5.15.4.1.3 Risk acceptance criteria are subject to approval by LR.

LR 5.15.4.2 A safety and reliability analysis is to be carried out to demonstrate that the liquefied gas transfer system ~~includes risk mitigation so that the~~ achieves a suitable level of safety and reliability ~~is equivalent to that associated with the current transfer of liquefied gas fluid from shore to ship (i.e., SIGTTO OCIMF). The analysis is to be carried out in accordance with acceptable National or International Standard.~~ It is to be shown that this is at least equivalent to that associated with terminal practises (i.e., EN 1474, SIGTTO, OCIMF, OGP). The analysis is to be carried out in accordance with acceptable National or International standards such as; ISO/IEC Guide 73, ISO 16903, ISO/TC 16901 and OGP Draft 118683 as well as the spirit of the Revised IGC Code.

LR 5.15.4.4 ~~The analysis is to be carried out in accordance with an acceptable industry or International Standard, using techniques appropriate for the analysis, and is to include arrangements to mitigate the potential effects of the hazards identified~~. When the analysis is to be carried out in accordance with land-based codes and standards, the acceptance criteria is to be verified as both appropriate and acceptable for the proposed transfer system when installed on the unit. The analysis is also considered the potential effects of any hazards identified as a result of abnormal conditions and is to include arrangements to mitigate any consequence.

LR 5.15.4.6 In order to facilitate the proper selection and installation of equipment to be used safely in areas where explosive gas atmospheres may occur, an area classification study, in accordance with ~~an alternative relevant International or National Standard such as IEC 60079-10-1, *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres*~~ Pt 7, Ch 2, 2 is to be carried out.

LR 5.15.4.7 To ensure that mechanical equipment located in hazardous areas does not represent a source of ignition, an ignition hazard assessment, in accordance with an acceptable National or International Standard such as EN13463-1, is to be carried out. *See* Pt 7, Ch 2, 5.1.2.

LR 5.15.4.9 ~~Conformance with the performance criteria, together with any specific requirements of the applicable Rules, standards and legislation~~ The transfer system is to be subject to both commissioning and acceptance trials to show compliance with both safety and operational performance criteria. The acceptance trials are to include operational testing and be witnessed by an attending Lloyd's Register Surveyor. All safety, operational and functional testing is to be demonstrated by the designer/Builder and Owner/Operator to the satisfaction of LR.

~~**LR 5.15.4.10** Where LR is acting on behalf of the Flag Authority, any relevant requirements of the Flag Authority are to be identified and advised to LR.~~

LR 5.15.7 Liquefied gas transfer system

LR 5.15.7.2 ~~Cargo transfer is usually accomplished by the use of hose(s) or loading arms (hard arms).~~ Transfer operations, accomplished by other means than transfer hoses and hard arms, will not be discounted but be given special consideration.

LR 5.15.8 Transfer hose

LR 5.15.8.5 ~~Hoses~~ Where required, hoses ~~of all types must be~~ are to be supported in a ~~hose~~ suitably dimensioned cradle or saddle arrangement to ensure that the manufacturer's ~~recommendations on minimum bending~~ bend radius criteria are met. These supports may be integral to the load restraint system thus preventing excessive axial and torsional loads on the cargo hose end fittings. ~~Their~~ The support's design, ~~load and security~~ fabrication and fixing arrangements shall be ~~considered, along with their~~ such to avoid chafing of the hoses and ability to prevent ~~chafing of the hoses(s) and their ability to avoid~~ damage to handrails and other unit fixtures and fittings in the event of ~~a separation of the ERC. Their design should ensure electrical isolation is maintained between the hose and the ship's structure~~ an emergency separation.

LR 5.15.8.5.1 Due to the difference in electrical potential between the unit and loading ship, there is a risk of an incendive arc when the transfer arms are being connected or disconnected. Arrangements shall be made to avoid the risk of arcing from this source by the installation of an insulating flange in the transfer arm or hose.

LR 5.15.8.5.2 Care shall be taken that the insulation flanges are not annulled by the use of electrically continuous hydraulic hoses.

LR 5.15.8.5.3 The use of a unit-to-loading ship bonding cable is not only considered ineffective but can also be dangerous if it breaks in a flammable atmosphere, such as where the final stage ESD activation includes automatic separation.

LR 5.15.8.7 In determining the size and length of the hose(s) to be used, the following, in accordance with the requirements of the SIGTTO Ship to Ship Transfer Guide for Petroleum, Chemicals and Liquefied Gases, ~~should~~ shall be considered:

- Minimum allowable bend radius of the hose;
- Horizontal distance between the ~~vessels~~ unit and ship;
- Difference in fore and aft alignment (manifold offset);
- Distance between the manifold and the ship's side;
- Vertical and horizontal ~~vessel~~ unit to ship movement;
- Any other special characteristics related to the ~~vessels~~ unit;
- Relative change in freeboard between the ~~vessels~~ unit and ship;
- ~~Flange~~ Accessibility of flange connections which are to be minimised ~~and accessible~~;
- ~~Allowable flow velocity;~~
- ~~Allowable pressure drop~~ Design flow rate for liquid and vapour hoses as established by the manufacturer;
- Hose handling requirements and limitations of the asset's equipment ~~on board the offshore unit.~~;
- For tandem offloading; the station-keeping accuracy of the loading ship or the maximum allowable elongation of the mooring hawser.

LR 5.15.8.9 Each hose is to be fitted with an emergency release coupling (ERC). The coupling is to be fitted with a valve, each side of the release point, which automatically closes before parting can occur. Manual activation of the coupling is also to be achievable.

LR 5.15.8.10 Operation of the ERC is to take place on activation of the emergency shutdown (ESD) system. The ERC is also to operate prior to the transfer hoses becoming over-extended. After activation, the resultant movement of the free end of the hose is to be such as to avoid the possibility of impact and sparking.

LR 5.15.9 Hard arm

LR 5.15.9.1 Where hard arms are considered for ~~use in~~ liquefied gas transfer operations, the following criteria, in accordance with the requirements of the SIGTTO Ship to Ship Transfer Guide for Petroleum, Chemicals and Liquefied Gases, ~~should~~ shall be taken into account:

- Accelerations;
- Permissible manifold loadings;
- Arm working envelope;
- Arm support arrangement;
- Arm stowage arrangement;
- The effect of vibration on the arm;
- Maintenance requirements;
- Size of the arm;
- Connectability;
- Vertical and horizontal ~~vessel~~ unit to ship movement;
- Allowable flow velocity and pressure loss;
- Testing requirements.

LR 5.15.9.2 ~~Inserting an insulating flange in the lower end of the outer hard arm.~~ An electrical insulation of the hard arm extremity shall be supplied according to the requirements of EN 1474-1. This may take the form of an insulating flange installed in the lower end of the outboard arm or within the middle swivel of the triple swivel assembly. The purpose of the flange is to prevent stray currents from causing an arc at the loading ship's flange as the loading arm is connected or disconnected.

LR 5.15.9.5 The physical disconnection may be achieved by means of a powered emergency release coupler (PERC). The effect of PERC activation and the resultant behaviour of the free arms are to be demonstrated. Consideration needs to be given to mitigating the effects resulting from unit motions and that the free arms can be controlled without impacting each other. If a manual type of loading arm is proposed (counter-weighted pantograph type), the furthest extent of the area which the released end of loading arm could extend into would need to be established.

LR 5.15.9.6 ~~The valve closure time should be such as to avoid surge pressure in pipelines. Such valves should close in such a manner as to cut off the flows smoothly.~~ The PERC valves shall close as quickly as reasonably possible with the valve closure time being sufficient to avoid unacceptable surge pressure in pipelines. Such valves should close in such a manner as to cut off the flows smoothly. An interlock shall be provided to ensure that both the upstream and downstream valves are closed prior to the emergency release coupling parting thus prevent or minimising loss of liquid.

LR 5.15.9.7 The powered emergency release coupler shall be equipped with a device or devices to prevent overpressure due to thermal expansion of trapped product between the valves which have been isolated due to the coupler's activation and resultant closure of the manifold valves due to activation of the ESD system.

LR 5.15.10 Drain system

LR 5.15.10.1 **General.** Once the transfer operation has been completed and the loading ship 'topped off', all liquid lines, transfer hoses and hard arms will be in a liquid full condition. To alleviate the possibility of overpressure within these lines, there is to be a means to either drain these lines back to the storage tanks or provide a suitable drain tank arrangement.

LR 5.15.10.2 It is envisaged that the loading ship will not have the ability or storage capacity to allow the liquid transfer lines to be blown through. Thus the trapped inventory, from the storage tank pump outlet check valve to the manifold valve of the hard arm or transfer hose, will need to be returned to the floating production unit.

LR 5.15.10.3 Where novel arrangements are used, such as over the stern tandem boom arrangement, the amount of trapped inventory may be considerable. If due to location there is not the ability to drain the trapped liquid back to the storage tanks then a separate collection and storage tank system is to be provided.

LR 5.15.10.4 Depending on the liquid being transferred, were sufficient high pressure gas can be generated on board the unit this can be used to blow back the trapped liquid back to the storage tank. If there is the ability to remove non-condensable gases from the storage tanks gaseous nitrogen may be used in lieu of high pressure gas. After blowing through, the headers and discharge lines shall be able to remain connected to the storage tank vapour space thus allowing any remaining puddle of liquid to be boiled off.

LR 5.15.10.5 Where required, such as over the stern tandem systems were their location is remote from the storage tanks, a drain down arrangement, complete with local collection tank, may be required. This may take the form of a collection tank, having the ability, through either pressurisation or pump, to return the drained inventory back to the storage tanks. Thus any liquid remaining in the boom, manifold and header after discharge is complete would to drain back to the collection tank by gravity.

LR 5.15.10.6 When a separate collection tank is installed it would need to be provided with dedicated set of equipment and systems to service the tank. These are to include; high level and high pressure alarms, a means to empty the collection tank, a relief valve and vent arrangement suitable for the set pressure of the relief valves and vent gas temperature.

LR 5.15.10.7 Where low points are generated in liquid headers or manifold were liquid may be trapped these are to be fitted with a means to drain them in accordance with 5.2.1.2.

5.7 Installation requirements
(*Part only shown*)

5.7.3 ~~**Cryogenic protection**~~ **Protection of steelwork and personnel against uncontrolled cryogenic release**

~~Cryogenic protection against spills is to be provided for temperatures below –110°C, such systems are to provide adequate coverage of hull, main decks, process decks, process support structures and other vulnerable equipment within the process area. These systems are to consider spillage, cryogenic jets and cryogenic pooling, and their size and scope are to be based on the process area inventories of the cryogenic material. The design of such systems is to ensure that they are constantly available and not reactive to an event.~~

~~Areas of the facility used for the discharge of cryogenic material may employ a water curtain for protection during such operations and is additional to the requirements of 11.3.1.4~~.

5.7.3.1 Requirements are to be provided to minimize the risks associated with the uncontrolled release of low temperature liquids. Such a release could result in evaporation and dispersion of the product and, in cases, could cause brittle fracture of unprotected hull, deck and support structures. In locations where a release of low temperature liquid could occur, suitable mitigation methods are to be provided. The techniques selected need to consider; the inventory volume, maximum liquid pressure, minimum liquid temperature and the location of possible leakage.

5.7.3.2 If drip trays and impoundment are used the material shall be selected to withstand exposure at the saturation temperature of the released liquid. The boundaries of the drip tray and impoundments are to be such to remain effective at the angles of inclination stated in Part 5, Chapter 1, Table 1.2.1 of the *Rules and Regulations for the Classification of Offshore Units.*

5.7.3.3 The effect of drip trays and impoundments containing low temperature liquid is not to effect supporting or adjacent steelwork. The fitting of thermal breaks to drip tray supports and insulation between impoundments and supporting steelwork structure is to be considered.

5.7.3.4 Where it is established that the liquid release may be substantial, the ability to drain drip trays and impoundments to be drained to an appropriate location or collection vessel is to be provided.

5.7.3.5 Unless the material has been selected accordingly, a water distribution system shall be fitted in way of the hull under the discharge connections to provide a low-pressure water curtain for additional protection of the hull steel and the side structure. This system is in addition to the requirements of 11.3.1.4, and shall be operated when discharging is in progress.

5.7.3.6 Personnel access ways, escape routes and refuge areas are to be protected against the possibility of uncontrolled release of low temperature liquids.

Part 11, Chapter 9

Cargo Containment System Atmosphere Control

Effective date 1 July 2015

9.4 Inerting

9.4.1 Inerting refers to the process of providing a non-combustible environment. Inert gases shall be compatible chemically and operationally at all temperatures likely to occur within the spaces and the cargo. The dew points of the gases shall be taken into consideration and be sufficiently low to alleviate the formation of ice or hydrates within the cargo tank or liquid pipework.

Part 11, Chapter 10

Electrical Installations

Effective date 1 July 2015

10.1 General requirements

10.1.2 Electrical installations shall be in accordance with ~~recognised Standards.~~ Pt 6, Ch 2 and Pt 7, Ch 2 where installations are located in hazardous areas. Reference is made to the recommendation published by the International Electrotechnical Commission, in particular to publication IEC 60092-502:1999 Electrical installations in ships - Part 502: Tankers – Special features.

10.1.5 To facilitate the selection of appropriate electrical apparatus and the design of suitable electrical installations, hazardous areas are divided into zones in accordance with recognised Standards such as Pt 7, Ch 2,1 and 2 or publication IEC 60092-502 *Electrical installations in ships - Part 502: Tankers* – Special features.

LR 10.1.2 Electrical equipment that is located in either enclosed or open non-hazardous areas and is to remain operational during catastrophic emergency conditions (i.e. major hydrocarbon release scenarios) is to be certified for operation in Zone 1 hazardous areas. However if such emergency equipment is not certified for operation in Zone 1 hazardous areas, the continued operation of this equipment maybe acceptable if it is demonstrated that the equipment is appropriately protected against potentially coming into contact with a flammable atmosphere by being located in an enclosed ~~safe~~ non-hazardous area, with appropriate mitigating measures (i.e. enclosed ~~safe~~ non-hazardous area is equipped with gas tight barriers, gas tight doors, rated gas dampers, suitable gas detection within the enclosure and its ventilation air intakes, etc.). *See* Pt 7 Ch 2,8.1.6.

Part 11, Chapter 11

Fire Prevention and Extinction

Effective date 1 July 2015

11.1 Fire safety requirements

LR 11.1.1 Fire prevention and fighting measures for the hull, hull weather deck and liquefied gas offloading facilities are generally to be in compliance with the following Sections, which reflect the requirements of the *International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk* (IGC Code). However, alternative fire protection and fire mitigating measures may be considered to be appropriate following assessment via the installation Fire and Explosion Evaluation (FEE), (*see* Part 7, Ch 3) dependent upon the ~~installation's~~ unit's fire-fighting and safety philosophy. The various requirements of Part 7 should also be fully referenced in connection with fire-fighting and fire mitigating measures. When referred to in this Chapter the hull and hull weather deck are intended to include the cargo area, the machinery spaces, the accommodation, service spaces and control stations in the hull and in the superstructure, but exclude the topside facilities, process plants, external or internal turrets, if fitted, or deckhouses therein.

11.1.1 In general, the requirements for tankers in SOLAS Chapter ll-2 are to apply to units covered by this Part, irrespective of tonnage of the unit, with the exception of the following:

.1 regulations 4.5.1.6 and 4.5.10 do not apply;

.2 regulation 10.2 as applicable to cargo ships, and regulations 10.4 and 10.5 are in general to apply to the hull structure of the installation, as they would apply to tankers of 2000 gross tonnage and over;

.3 regulation 10.5.6 is to apply to the machinery spaces in the hull structure;

.4 the following regulations of SOLAS Chapter II-2 related to tankers do not apply and are replaced by the Chapters and Sections of this Part as detailed below:

Regulation	**Replaced by**
10.10	Part 11, 11.6
4.5.1.1 and 4.5.1.2	Part 11, Chapter 3
4.5.5	Relevant Chapters and Sections in this Part
~~and~~ 10.8	Part 11, 11.3 and 11.4
10.9	Part 11, 11.5
10.2	Part 11, 11.2.1 to 11.2.4

.5 regulations 13.3.4 and 13.4.3 shall apply to the ~~ship unit~~ hull and hull weather deck.

LR 11.1.3 ~~For the hull structure of the unit~~ In the hull, all sources of ignition should be excluded from spaces where flammable vapour may be present, except as otherwise provided in Chapter 10 and Chapter 16. For the topsides areas of the unit, sources of ignition should be minimised where practicable, but must always be certified for any defined hazardous area in which it is intended to operate. *See also* Pt 7, Ch 1 and 2 with regard to mitigation of ignition risks.

11.2 Fire mains and hydrants

11.2.1 All ship units, irrespective of size, with bulk liquefied gas storage and/or vapour discharge and loading manifolds/facilities, carrying products specified in Chapter 19 are in general to comply with the requirements of SOLAS regulations II-2/10.2, except that the required fire pump capacity and fire main and water service pipe diameter should not be limited by the provisions of regulations II-2/10.2.2.4.1 and II-2/10.2.1.3. When a fire pump is used as part of the water spray system, as permitted by 11.3.3 of this Chapter, the capacity of this fire pump shall be such that these areas can be protected when simultaneously supplying two jets of water from fire hoses with 19 mm nozzles at a pressure of at least 5,0 bar gauge for hydrants located at hull, hull weather deck and liquefied gas offloading facilities. For hydrant located on topsides facilities, the pressure should be at least 3,5 bar gauge for two operational hydrants at the hydrant outlet valve upstream of the utilised hydrant hose.

LR 11.2.1 In addition to 11.2.1, the fire pump capacity and fire main should be sized to supply all credible fire water demands associated with a credible installation fire scenario determined via the Fire and Explosion Evaluation (FEE).

11.2.2 The arrangements shall be such that at least two jets of water can reach any part of the deck in the cargo area, those portions of the cargo containment system and tank covers that are above the deck, and topside areas. The necessary number of fire hydrants shall be located to satisfy the above arrangements and to comply with the requirements of SOLAS regulations II-2/10.2.1.5.1 and II-2/10.2.3.3, taking into account the length of the hoses used at the location. The hose length should not be greater than 15 m in hull machinery spaces and should not be greater than 20 m in topsides areas, due to space constraints to enable the hose to be laid out by a fire team in a fire incident. In addition, the requirements of regulation II-2/10.2.1.6 shall be met at a pressure of at least 5.0 bar gauge at the hydrant outlet valve upstream of the utilised hydrant hose.

LR 11.2.2 For the purpose of application of 11.2.4, the capability to remain functional is to be regarded as the ability of the system to perform its function after exposure to the indicated temperature. That may be demonstrated using components and materials of suitable characteristics and of an approved type, where applicable.

11.3 Water-spray system

~~**LR 11.3.1** Water spray fire-fighting measures for the hull, hull weather deck and liquefied gas offloading facilities are generally to be in compliance with the following Sections, which reflect the requirements of the *International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk* (IGC Code). However, alternative fire protection and fire mitigating measures may be considered to be appropriate following assessment via the installation Fire and Explosion Evaluation (FEE), dependent upon the installation's fire-fighting and safety philosophy. The various requirements of Part 7 should also be fully referenced in connection with fire-fighting and fire mitigating measures.~~

~~*11.3.4*~~ **LR 11.3.1** The maximum credible firewater demand should be determined in the installation Fire and Explosion Evaluation (FEE) based on the credible activation of water spray systems detailed in 11.3 and any additional topside module and hydrant demands. ~~**LR 11.3.2**~~ The installation main firewater pumps should be sized suitably to supply the defined maximum credible firewater demand. The installation design should incorporate a suitable allowance for firewater pump redundancy. This redundancy is to allow for failure of a firewater pump on demand or loss of a firewater pump for maintenance without incurring potential lost production on the installation due to the loss of firewater supply. Permanently manned hydrocarbon installations typically have two 100 per cent or three 50 per cent firewater pumps designed to meet the installation's defined largest credible firewater demand scenario (i.e., the installation's 100 per cent firewater demand). However, other configurations of firewater pump supply redundancy may be acceptable for an installation, subject to suitable demonstration (for example, normally unmanned installations often do not have any dedicated firewater pumps).

~~*11.3.5*~~ *11.3.4* Water pumps normally used for other services may be arranged to supply the water-spray application system main supply line. However, the suitability and reliability of any such pump would need to be demonstrated as equal to that required by a defined firewater pump.

LR 11.3.3~~2~~ The provision of fixed firewater fire-fighting facilities over topsides process module areas should be established based on the fire-fighting risks and philosophy derived for the installation via the Fire and Explosion Evaluation (FEE).

Existing paragraphs 11.3.6 *to* 11.3.8 *have been renumbered* 11.3.5 *to* 11.3.7.

11.4 Dry chemical powder fire-extinguishing systems

~~**LR 11.4.1** Dry chemical fire-fighting measures for the hull, hull weather deck and liquefied gas offloading facilities are generally to be in compliance with the following Sections, which reflect the requirements of the *International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk* (IGC Code). However, alternative fire protection and fire mitigating measures may be considered to be appropriate following assessment via the installation Fire and Explosion Evaluation (FEE), dependent upon the installation's fire-fighting and safety philosophy. The various requirements of Part 7 should also be fully referenced in connection with fire-fighting and fire mitigating measures.~~

11.4.1 Dependent upon the conclusions of the Fire and Explosion Evaluation (FEE) and the installation's fire-fighting and safety philosophy, consideration for ship units should be given to the provision of fixed dry chemical powder fire-extinguishing systems, complying with the provisions of the ~~FSS Code~~ Guidelines developed by IMO (IMO (MSC.1/Circ. 1315)), for the purpose of fire-fighting on the deck in the cargo area, including all cargo liquid and vapour discharge and loading connections on deck and cargo handling areas as applicable. Should a system not be fitted as a result of the conclusions mentioned above, final acceptance of the proposal should be to the satisfaction of the Flag Administration, if applicable.

11.5 Enclosed spaces containing cargo handling equipment

LR 11.5.1 Cargo machinery spaces shall be protected by an appropriate fire-extinguishing system for the cargo carried. The system is to be of a type acceptable to LR, and approved by the unit's Flag Administration (if applicable).

~~11.5.2~~ **LR 11.5.2** The fire risks associated with the turret compartments of any ship unit are to be fully assessed within the installation Fire and Explosion Evaluation (FEE). The firefighting/mitigating measures associated with the turret (i.e. water spray, passive fire protection, isolation and blowdown, etc.) are to be based upon the fire risks determined within the Fire and Explosion Evaluation (FEE) and should be in line with the overall installation's fire-fighting and safety philosophy.

LR 11.7 Passive Fire protection systems

LR 11.7.1 In addition to Pt 7, Ch 3,3.6, Passive Fire Protection Systems and their components, when installed in locations where they may be exposed to releases of cryogenic products, should take into account the impact of such release on their performance and rating.

Part 11, Chapter 12

Artificial Ventilation in the Cargo Area

Effective date 1 July 2015

12.1 Spaces required to be entered during normal cargo handling operations

12.1.4 Where a space has an opening into an adjacent more hazardous space or area, it shall be maintained at an over-pressure. It may be made into a less hazardous space or non-hazardous space by over-pressure protection in accordance with recognised Standards such as IEC 60092-502:1999 *Electrical installations in ships - Part 502: Tankers – Special features*.
Where the hazard in the adjacent more hazardous space is a potential flammable or explosive gas air mixture, and the space in question is to be classified as a non-hazardous or less hazardous area as per hazardous area classification see Pt 7, Ch 2,2, the adjacent more hazardous space shall be maintained with an underpressure of at least 50 Pa in relation to the space in question, to comply with Part 7 Chapter 2 Section 6.2.2.

12.1.7 Electric motors driving fans shall be placed outside the ventilation ducts that may contain flammable vapours. Ventilation fans shall not produce a source of ignition in either the ventilated space or the ventilation system associated with the space. For hazardous areas, ventilation fans and ducts, adjacent to the fans, shall comply with Pt 7 Ch 2,5.1.2 and be of non sparking construction, as defined below:

.1 impellers or housing of non-metallic construction, with due regard being paid to the elimination of static electricity;
.2 impellers and housing of non-ferrous materials;
.3 impellers and housing of austenitic stainless steel; and
.4 ferrous impellers and housing with not less than 13 mm design tip clearance.

Any combination of an aluminium or magnesium alloy fixed or rotating component and a ferrous fixed or rotating component, regardless of tip clearance, is considered a sparking hazard and shall not be used in these places.

Part 11, Chapter 16

Use of Cargo as Fuel

Effective date 1 July 2015

16.5 Fuel gas plant and related storage tanks

16.5.1 **Provision of fuel gas**
All equipment (heaters, compressors, vaporisers, filters, etc.) for conditioning the cargo and/or cargo boil off vapour for its use as fuel, and any related storage tanks, shall be located in the cargo or topside areas. If the equipment is located in an enclosed space the space shall be ventilated according to 12.1, ~~and~~ be equipped with a fixed fire-extinguishing system, according to 11.5, and with a gas detection system according to 13.6, as applicable.

Part 11, Chapter 20

Barges and Offshore Units Equipped with Regasification

Effective date 1 July 2015

LR 20.1 General

LR 20.1.1 Goal

LR 20.1.1.1 The goal of the Rules contained in this Section is to provide for the safe regasification of liquefied natural gas (LNG), minimising the risk to the barge or offshore unit, its crew and to the environment by specifying requirements for the design, construction and installation of regasification systems on board barges or offshore units having regard to the nature of the products including; flammability, toxicity, asphyxiation, corrosivity, reactivity, temperature and pressure.

LR 20.1.2 Application

LR 20.1.2.1 The requirements of these Rules apply to barges and offshore units that are equipped with regasification systems and associated sub-systems.

LR 20.1.2.2 Dependent on the barge or offshore unit service and regasification operational location, requirements additional to these Rules may be imposed by the National Authority with whom the barge or offshore unit is registered and/or by the Administration within whose territorial jurisdiction the barge or offshore unit is intended to operate.

LR 20.1.2.3 The Rules do not repeat the general requirements for fire safety as stated in statutory conventions. These Rules do, however, include fire safety requirements additional to those stated in the statutory conventions that are specific to the construction and equipment of regasification systems.

LR 20.1.2.4 Unless requested, classification will not include those systems which are additional to the regasification, heating and 'send-out' process equipment such as; blending facilities, odorizers, or dew point correction/dehumidification, except where the design and/or arrangements of such equipment and piping may affect the safety of the vessel.

LR 20.1.3 Class notation

LR 20.1.3.1 The following notations may be assigned as considered appropriate by the Classification Committee, on application from the Owners:

⊠**Lloyd's RGP** - This notation will be assigned when a regasification system and arrangements have been constructed, installed and tested under Lloyd's Register's (hereinafter referred to as LR's) Special Survey and in accordance with the relevant requirements of the Rules.

⊠**Lloyd's RGP+** - This notation will be assigned when a regasification system and arrangements have been constructed, installed and tested under LR's Special Survey and in accordance with the relevant requirements of the Rules and the system is configured to allow continuing operation in the event of a single failure.

LR 20.1.4 Survey

LR 20.1.4.1 The regasification plant and its sub-systems and equipment shall be installed and tested to the Surveyor's satisfaction.

LR 20.1.4.2 All regasification plant and sub-systems shall be subject to the following surveys:

(a) an Initial Survey before the regasification system is put into service, which should include a complete examination of its structure, equipment, fittings, arrangements and materials of the regasification system. This survey should be such as to ensure that the structure, equipment, fittings, arrangements and material fully comply with the applicable provisions of these Rules;

(b) a Complete Survey at intervals specified by the LR, but not exceeding 5 years. The Complete Survey should be such as to ensure that the structure, equipment, fittings, arrangements and material fully comply with the applicable provisions of these Rules and are in good working order;

(c) an Intermediate Survey within 3 months before or after the second anniversary date or within 3 months before or after the third anniversary date of the Certificate which should take the place of one of the annual surveys specified in LR 20.1.4.2 (d). The Intermediate Survey should be such as to ensure that the safety equipment, and other equipment, and associated pump and piping systems fully comply with the applicable provisions of these Rules and are in good working order;

(d) an Annual Survey within 3 months before or after each anniversary date of the Certificate, including a general inspection of the structure, equipment, fittings, arrangements and material of the regasification system to ensure that they have been maintained in accordance with Section LR 20.1.4.6, and that they remain satisfactory for the service for which the barge or offshore unit is intended;

(e) an additional survey, either general or partial according to the circumstances, should be carried out when required after

an investigation prescribed in LR 20.1.4.8, or whenever any significant repairs or renewals are made. Such a survey should ensure that the necessary repairs or renewals have been effectively made, that the material and workmanship of such repairs or renewals are satisfactory, and that the regasification unit remains in accordance with the requirements of these Rules and other relevant standards.

LR 20.1.4.3 Surveys referred to in LR 20.1.4.2 are to be in accordance with Pt 1, Ch 3, Sections 6, 9, 14, 17 and 18, as applicable.

LR 20.1.4.4 In addition to the survey and certification of equipment required by relevant Sections of these Rules, the major items of equipment included in the regasification system are required to be constructed under survey at the manufacturer's works. These include, but are not limited to, vaporisers, heat exchangers and their circulating pumps, LNG booster pumps and gas compressors.

LR 20.1.4.5 Where the ⊠ **Lloyd's RGP+** notation is assigned, the means of providing continuing operation in the event of a single failure, as demonstrated in the dependability assessment, *see* LR 20.3.3, is to be examined and tested as part of the commissioning trials, *see* LR 20.8.2, to ascertain that the system will continue to operate.

LR 20.1.4.6 The condition of the regasification system shall be maintained in accordance with the provisions of these Rules to ensure that the system remains fit to operate without danger to the barge, offshore unit or persons and without presenting unreasonable threat of harm to the marine environment.

LR 20.1.4.7 After any survey of the regasification system has been completed, no change should be made in the structure, equipment, fittings, arrangements and material covered by the survey, without the sanction of LR, except by direct replacement.

LR 20.1.4.8 Wherever an accident occurs to a regasification system or a defect is discovered, either of which affects the safety of the barge, offshore unit or regasification system, the efficiency or completeness of its life-saving appliances or other equipment covered by these Rules, the Operator or Owner of the barge or offshore unit should report at the earliest opportunity to LR, who should cause investigations to be initiated to determine whether a survey, as required by LR 20.1.4.2 (e), is necessary.

LR 20.1.4.9 Unless they form part of the classed equipment, surveys will not include those systems which are additional to the send-out process plant equipment, such as blending facilities, odorizers, dew point correction/dehumidification, except where the design and/or arrangements of such equipment and piping may affect the safety of the barge or offshore unit.

LR 20.1.5 Definition

LR 20.1.5.1 Area means a defined location. An area can be on open deck. An area can be open, semi-enclosed or enclosed. An area can be a space below deck. An area can be hazardous or none-hazardous.

LR 20.1.5.2 Blowdown is defined as the depressurisation of a system, part of a system and its equipment to allow the safe disposal of both vapour and liquid discharged from blowdown valves. Depressurisation is used to mitigate the consequences of a pipeline or vessel leak by reducing the leakage rate and/or inventory within the pipe or vessel prior to a potential failure.

LR 20.1.5.3 Dependability is as defined in IEC 60050(191): *Quality vocabulary – Part 3: Availability, reliability and maintainability terms – Section 3.2: Glossary of international terms*. It is the collective term used to describe the availability performance and its influencing factors: reliability performance, maintainability performance and maintenance support performance and relates to essential services as agreed with LR. Note: Dependability is used only for general descriptions in none-quantitative terms.

LR 20.1.5.4 Enclosed space is any space within which, in the absence of artificial ventilation, the ventilation will be limited and any explosive atmosphere will not be dispersed naturally. In practical terms, this is a space bounded either on all sides, or all but one side, by bulkheads and decks irrespective of openings, such that the required ventilation rate to prevent the accumulation of pockets of stagnant air cannot be achieved by natural ventilation alone.

LR 20.1.5.5 Essential services are:

- those systems, sub-systems and equipment required to provide continued safe operation of the regasification system; and as defined by Pt 6, Ch 2,1.6.2.

LR 20.1.5.6 Gasification is the process of heating a saturated vapour (NG) by the addition of heat from an external source, above its saturation temperature.

LR 20.1.5.7 '**Gas Safe Space**' is a space that lies wholly outside a gas dangerous space or zone or is one that is engineered as a gas safe place within certain gas dangerous spaces or zones as required in these Rules.

LR 20.1.5.8 Hazardous area is as defined in IEC 60079-10-1: *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres*.

LR 20.1.5.9 High pressure refers to systems, equipment and components containing LNG with a design pressure greater than 10 bar g.

LR 20.1.5.10 Novel design: designs of machinery and engineering systems that are considered by LR to be unconventional.

LR 20.1.5.11 A **Reasonably foreseeable abnormal condition** is an event, incident or failure that:

- has happened and could happen again;
- Is planned for (e.g. emergency actions cover such a situation, maintenance is undertaken to prevent it, etc.).

LR 20.1.5.12 Regasification System is the complete gasification process plant from LNG storage tanks to the gas export (send-out) shore connection including regasification unit, suction drum, associated pumping, piping and sub-systems.

LR 20.1.5.13 Regasification Unit is referring to vaporisers, heaters, LNG booster pump and associated piping intended for the gasification of LNG from the storage tanks.

LR 20.1.5.14 Risk assessment is the evaluation of likelihood and consequence together with a judgement on the significance of the result, *see* IEC/ISO 31010: *Risk management, risk assessment techniques*.

LR 20.1.5.15 Risk: the combination of the likelihood of an event and its consequence. Likelihood may be expressed as a probability or a frequency.

LR 20.1.5.16 Send-out is the discharge of the high pressure gas after the vaporisation and heating process. Send-out may include additional processes, such as trim heating, calorific correction, odorization, or dew point correction/ dehumidification.

LR 20.1.5.17 Vaporisation is the controlled boiling of a liquid (in this case LNG) due to the addition of heat from an external source.

LR 20.1.5.18 Vent Mast: Discharges from relief valves and purging systems are carried to the atmosphere through vent masts, the outlets of which are designed to promote vapour dispersal and reduce the risk of flammable mixtures being produced.

LR 20.1.5.19 Other appropriate definitions as indicated in other Chapters of these Rules and the Rules for Ships.

LR 20.2 Submission of plans and documentation

LR 20.2.1 General

LR 20.2.1.1 Documentation, together with the relevant information as detailed in this Section, shall be submitted for consideration.

LR 20.2.1.2 Any alterations to basic design, construction, materials, manufacturing procedure, equipment, fittings or arrangements of the process shall be re-submitted for approval before the regasification plant is put into operation.

LR 20.2.2 Systems and arrangements

LR 20.2.2.1 The plans and information required by relevant Sections of these Rules are to be submitted for appraisal.

LR 20.2.2.2 System description document: a description of the arrangements and the intended operating philosophy, design criteria and functionality of the regasification system. It shall include the following information:

(a) Particulars of piping arrangements and control systems, including material specifications, design pressures, design temperatures, ambient design temperatures and control system operational specification;

(b) Operating design criteria that may include, as applicable:
  (i) design maximum throughput and turn-down ratio in both open and closed loop operation. For closed loop operation, the maximum available heat input is also to be stated;
  (ii) design maximum discharge gas pressure and minimum gas superheat;
  (iii) the maximum and minimum permissible variations from the design operating conditions;
  (iv) the maximum permissible back pressure allowed in the gas send-out system;
  (v) design maximum transfer rates where ship LNG transfer is undertaken and the method and control used to handle boil-off gas and displacement gas to and from the offloading vessel;
  (vi) the minimum required gas output for a specific sea-water temperature and throughput, when applicable;
  (vii) for open loop systems the maximum LNG throughput at various seawater inlet temperatures;
  (viii) for closed loop systems the output of the boiler or alternative heating arrangement;
  (ix) for open loop systems the minimum allowable sea-water outlet temperature;
  (x) for closed loop systems the design minimum temperature and throughput of the heated water or heat transfer fluid.

(c) Procedures for connecting/disconnecting the gas send-out pipeline and LNG transfer arms or hoses. Details of the isolation arrangements and inerting and gas-freeing of the send-out and LNG pipework;

(d) Emergency procedures to be followed during regasification and barge or offshore unit-to-ship operations. These shall include guidance on procedures to be followed in the event of closure of the land-based send-out gas master valve;

(e) Specified availability and extent and periodicity of contract down-time.

LR 20.2.2.3 Risk based analysis undertaken to a recognised Standard in accordance with LR's ShipRight procedure '*Assessment of Risk Based Designs*' and the associated Annex on LNG. The analysis shall be documented so that the risks and

how they are eliminated or mitigated are clearly identified, and an appropriate level of safety, dependability and hazardous area classification is demonstrated.

LR 20.2.2.4 Regasification barge or offshore unit general arrangement. Plans showing the arrangement of all areas where equipment, components and piping systems are located.

LR 20.2.2.5 Plans for vaporisers, heat exchangers (shell/tube, printed circuit and plate type), LNG drum, liquid receivers and other pressure vessels (*see also* Pt 5, Ch 11).

LR 20.2.2.6 Plans and documents as required by Pt 6, Ch 1, showing the automatic controls, alarms and safety systems associated with the regasification system.

LR 20.2.2.7 The thermodynamic calculations confirming the design send-out rates for the vaporisers.

LR 20.2.2.8 Capacity calculations for pressure relief valves and discharge pipe vent stack pressure drop calculations.

LR 20.2.2.9 Piping information is to include:

(a) schematic plans, including full particulars of piping and instrumentations for:
  (i) low and high pressure LNG supply pipework;
  (ii) primary and secondary thermal fluid systems;
  (iii) heating system for closed loop operation;
  (iv) depressurisation system (knock-out drum and shock load verification arrangements);
  (v) barge or offshore unit LNG manifold and transfer arrangements;
  (vi) high pressure gas send-out systems;
  (vii) cooling water systems;
  (viii) other associated ancillary systems.
(b) details of means of draining, inerting, and gas-freeing of the regasification pipework, equipment and components;
(c) pipework and equipment insulation arrangements;
(d) protection of barge or offshore units structure, pipework and equipment against cryogenic leakage;
(e) pipe stress analysis. A complete stress analysis as required by Pt 11, Ch 5, Section 11.5 of applicable pipework.

LR 20.2.2.10 Hazardous Area Plan for regasification equipment and send-out system.

LR 20.2.2.11 Interfaces: plans and documents detailing the barge or offshore unit to regasification system interfaces.

LR 20.2.2.12 Safety system plans: fire-fighting details, gas detection details, fire and general alarm details, all related to the regasification system and to the send-out arrangements. They shall be included in the main safety system plans of the vessel for approval in accordance with these Rules.

LR 20.2.2.13 Escape plan: details of the arrangements for protection and safe escape in relation to the regasification system and send-out arrangements.

LR 20.2.2.14 An emergency shutdown (ESD) system cause and effect matrix that shall cover the additional operational scenarios of regasification and barge or offshore unit LNG transfer. This shall be integrated with the ESD main system matrix of the vessel. Where an ESD initiation results in multiple actions, the matrix shall indicate these in the order in which they will be performed.

LR 20.2.2.15 A functional flow chart of the ESD system and connected systems shall be provided which aligns with the cause and effect matrix and details the functions provided by ESD System. A copy shall be maintained at the regasification control station and on the central control room.

LR 20.2.2.16 A process shutdown (PSD), cause/effect matrix and design philosophy.

LR 20.2.2.17 Details of depressurisation and high pressure blowdown philosophy and arrangements.

LR 20.2.2.18 Ancillary systems or additional equipment such as blending facilities, odorizers, dew point correction/ dehumidification, control and monitoring facilities where these are to be considered as part of the classed equipment.

LR 20.2.2.19 Operating manuals shall be submitted. The content of the manuals shall include but not be limited to:

(a) particulars and a description of the systems;
(b) overall operation of the system, including procedures for planned start-up and shutdown;
(c) maintenance instructions for the installed equipment, systems and arrangements;
(d) temperature and pressure control systems;
(e) system limitations, including minimum temperatures, maximum pressures, transfer rates;
(f) special procedures associated with fire-fighting where different from barge or offshore unit's systems;
(g) details of fixed gas detection where additional to the barge or offshore unit's fitted systems;
(h) control, alarm and safety systems;
(j) emergency and process shutdown systems, including pressure relief and blowdown;
(k) emergency procedures, including isolation from LNG storage tank.

LR 20.3 Risk based analysis

LR 20.3.1 Purpose

LR 20.3.1.1 The purpose of the risk based analysis is to:
(a) evaluate safety considerations that are specific to the regasification and send-out equipment, *see* 20.3.2;
(b) evaluate dependability of the regasification plant, *see* 20.3.3;
(c) specially consider arrangements which deviate from the requirements of these Rules, *see* 20.3.2.

LR 20.3.2 System safety risk assessment

LR 20.3.2.1 The objectives of the assessment are to:
(a) Evaluate safety risks associated with the use of the regasification system where the requirements within the Rules are not satisfied;
(b) Evaluate safety risks associated with the use of the regasification system where specifically required by the Rules;
(c) for LR 20.3.2.1(a) and LR 20.3.2.1(b), demonstrate that an appropriate level of safety is achieved, which is commensurate with that generally accepted for the containment of LNG cargoes through compliance with these Rules.

LR 20.3.2.2 Where the risks cannot be eliminated, an inherently safer design shall be sought in preference to operational/procedural controls. This shall focus on engineered prevention of failure (e.g. minimised number of connections, increased reliability, and redundancy).

LR 20.3.2.3 The risk assessment may identify the requirement for safety measures in addition to those specifically stated in these Rules.

LR 20.3.2.4 The scope of the risk assessment may include but not be limited to:
(a) normal operation, start-up, normal shutdown, non-use, and emergency shutdown of the system, during:
- pressurised gas discharge to shore; high pressure gas venting;
- storage and handling of flammable or toxic secondary heat transfer fluids (as applicable);
- continuous presence of liquid and vapour cargo outside the cargo containment system;
- Barge or offshore unit-LNG transfer.

(b) physical layout of machinery and equipment including extension of hazardous areas and evacuation arrangements;
(c) fire and explosion, process upset conditions, over-pressure and under-pressure, mechanical and electrical failures and human error. Consideration being given to the effects of pool and jet fires;
(d) the effect of cryogenic spills and pressurised leaks.

LR 20.3.2.5 The risk assessment shall be undertaken by suitably qualified and experienced individuals to a recognised Standard (e.g. as outlined in ISO/IEC 31010-2009: *Risk management – Risk assessment techniques*) in accordance with LR's ShipRight Procedure *Assessment of Risk Based Designs* and the associated Appendix on LNG.

LR 20.3.2.6 The risk assessment shall be assessed in accordance with Ch 5, LR 5.15.8.7*,* and:
(a) analysis of risk associated with the barge or offshore unit-to-ship LNG transfer in accordance with ISO 28460:2010 *Petroleum and natural gas industries – Installation and equipment for liquefied natural gas – Ship-to-shore interface and port operations* and the relevant parts of EN 1474 as applicable, and SIGTTO LNG *Ship-to-Ship Transfer Guide for Petroleum, Chemicals and Liquefied Gases*.
(b) process upsets associated with the land-based receiving systems;

LR 20.3.3 System dependability

LR 20.3.3.1 Where Class Notation ✠ **Lloyd's RGP+** is to be assigned, an assessment shall be carried out to demonstrate that a fault in any active component or system will not result in reduced availability of the plant to send-out gas.

LR 20.3.3.2 The level of availability of the regasification system shall be specified by the Owner or operator, *see* LR 20.2.2.2.

LR 20.3.3.3 The assessment shall be undertaken by suitably qualified and experienced individuals using approaches acceptable to LR.

LR 20.4 System Design

LR 20.4.1 General

LR 20.4.1.1 Materials, components and equipment to be used in the construction of regasification systems shall be suitable for the intended service conditions and acceptable to LR. The materials, components and equipment shall also satisfy the requirements of this Section.

LR 20.4.1.2 Materials shall comply with the requirements of the *Rules for the Manufacture, Testing and Certification of Materials* (hereinafter referred to as the Rules for Materials) and Pt 11, Ch 6.

LR 20.4.1.3 The design, arrangements and selection of equipment shall be such as to minimise the risk of fire and explosion

from flammable products.

LR 20.4.1.4 Electrical components and equipment shall comply with Section LR 20.7.

LR 20.4.1.5 Any single failure of the regasification system shall not result in a hazard that affects safety.

LR 20.4.1.6 The regasification barge or offshore unit shall have adequate capability for managing the boil-off gas generated by heat ingress through headers, manifolds flexible hoses and loading arms during barge or offshore unit-to-ship transfer operations.

LR 20.4.1.7 The regasification system shall include provision to pre-cool the product transfer piping system prior to barge or offshore unit-to-ship transfer operations commencing.

LR 20.4.2 Vaporisers

LR 20.4.2.1 The requirements of these Rules apply to various types and designs of vaporiser and process units, such as:

- Heat exchanger designs including:
  STV – Shell and tube heat exchanger type.
  PCHE – Printed circuit heat exchanger.
  AHHE – Air heated heat exchanger utilising forced ventilation.
  CWHE – Coil wound heat exchanger.
- ORV – Open rack type utilising sea-water or a circulating intermediate heated fluid.
- SCV – Submerged combustion type utilising the heat of combustion of either oil or send-out gas.

LR 20.4.2.2 Vaporising units of novel design, making use of materials not covered by the Rules, will be subject to special consideration and subject to the requirements of Pt 7, Ch 14 of the Rules for Ships, '*Requirements for machinery and engineering systems of unconventional design*'.

LR 20.4.2.3 The manufacture, installation and testing of vaporisers, including the intermediate heat transfer vessels and pumping systems, shall be undertaken in accordance with these.

LR 20.4.2.4 All LNG high pressure pumps supplying vaporisers, which are capable of developing a pressure exceeding the design pressure of the system into which they are pumping, are to be provided with relief valves in closed circuit.

LR 20.4.2.5 For STVs and ORVs, sea-water may be used as a primary heat source for vaporisation. An intermediate heat transfer fluid may be proposed to reduce the chance of freezing and effects of corrosion.

LR 20.4.2.6 Where sea-water is used as the source of heat to vaporise the LNG, the tubes shall be manufactured from a corrosion-resistant material, taking into consideration the type and temperature of media conveyed. Where the ⊠ **Lloyd's RGP+** Notation is to be assigned, suitable redundancy of the sea-water circulation pump and LNG high pressure supply pumps shall be provided.

LR 20.4.2.7 When an intermediate heat transfer fluid is used, and where the ⊠ **Lloyd's RGP+** Notation is to be assigned, dual compressors or circulating pumps shall be provided. Where the heat transfer fluid goes through a phase change, the applicable Sections of Pt 6, Ch 3 shall be complied with.

LR 20.4.2.8 Where potential risk of failure of a tube or passage could result in gas entering the sea-water side:

(a) the sea-water side shall be designed to accept the full gas pressure of the gas side;

(b) the sea-water side shall be protected with bursting discs or relief valves in readily visible positions; the discharge from these bursting discs or relief valves shall be taken to a suitable high-pressure venting arrangement and the number and position of bursting discs or relief valves shall be adequate to relieve the flow occurring due to failure of a single tube.

LR 20.4.2.9 If steam is used in a heat exchanger containing LNG, propane or other flammable gas, the condensate shall not be passed directly back to the machinery room. The steam-condensate shall be passed through a degassing tank located in a gas-dangerous area. The vent outlet from the degassing tank shall be routed to a safe location and be fitted with a flame screen. The degassing tank shall be fitted with a gas detection and alarm system, *see* Part 11, Ch 13,13.6.

LR 20.4.2.10 If the barge or offshore unit is to operate in regions where insufficient natural sources of heat are available for vaporisation, e.g. due to low sea-water temperature, the design gas output conditions shall be maintained utilising alternative means.

LR 20.4.2.11 Where alternative means of heating the LNG are required, an independent gas or oil supply system shall be provided to facilitate initial start-up.

LR 20.4.2.12 The regasification system may operate with a dual heat source with, for example, a mixture of heat inputs from sea-water and a boiler.

LR 20.4.2.13 Where aluminium alloy vertical tubes and horizontal headers are constantly covered with sea-water, adequate protection against corrosion shall be provided.

LR 20.4.2.14 Commissioning and testing of vaporisers may be undertaken by the manufacturer prior to units being installed on board in accordance with LR 20.8.2.

LR 20.4.2.15 Water supply pumps shall be fitted with suitable inlet filters. It shall be possible to remove and clean the filters whilst the regasification system remains operational. Any regasification system-related sea-water inlet shall be fitted with gratings and provision made to allow cleaning by low pressure steam or compressed air.

LR 20.4.2.16 A water treatment system shall be incorporated for use with submerged combustion vaporisers to eliminate degradation of the tubes.

LR 20.4.2.17 The submerged combustion vaporisers shall comply with the relevant Sections applicable to inert gas generators and steam boilers operating with boil-off gas, as applicable, stated in Pt 11, Ch 7 and Pt 5, Chs 10 and 11.

LR 20.4.3 Gas detection system

LR 20.4.3.1 In addition to the gas detection system fitted to allow compliance with Pt 11, Ch 13, a permanently installed system of gas detection and audible and visual alarms is to be fitted in:
(a) all enclosed spaces containing gas piping, liquid piping or regasification equipment;
(b) other enclosed or semi-enclosed spaces where gas vapours may accumulate;
(c) air-locks;
(d) secondary fluid expansion tanks;
(e) the condensate degassing tank.

LR 20.4.3.2 Gas detection equipment is to be designed, installed and tested in accordance with IEC 60079-29-1, an is to be suitable for the gases to be detected.

LR 20.4.3.3 The number and the positions of detection heads or sampling heads is to be determined with due regard to the size and layout of the semi-enclosed space or compartment and be in accordance with the equipment manufacturer's recommendations. Due regard is to be given to the air flow from compartment ventilation inlets and outlets.

LR 20.4.3.4 The gas detection system serving the regasification plant may be either independent or combined with the gas detection system installed to allow compliance with Pt 11, Ch 13.

LR 20.4.3.5 The gas detection is to be of the continuous monitoring type, capable of immediate response.

LR 20.4.3.6 The gas detection system serving the regasification plant is otherwise to comply with the construction and Installation requirements of Pt 11, Ch 13.

LR 20.4.4 Emergency shutdown (ESD) system

LR 20.4.4.1 An emergency shutdown (ESD) system serving the regasification plant and sub-systems and equipment shall be fitted and shall comply with the cause and effect matrix shown in Table LR 20.4.1 as applicable.

LR 20.4.4.2 The ESD system shall be activated by the manual and automatic inputs listed in Table LR 20.4.1. Any additional inputs shall only be included in the ESD system if it can be shown that their inclusion does not reduce the integrity and reliability of the system overall.

LR 20.4.4.3 The ESD system shall return the regasification system to a safe static condition, allowing remedial action to be taken. Due regard shall be given in the design of the ESD system to avoid the generation of surge pressures within both the liquid and vapour pipework.

LR 20.4.4.4 The equipment to be shut down on ESD activation shall include manifold valves during loading or discharge, and pumps and compressors associated with transferring LNG and NG.

Table LR 20.4.1 ESD functional arrangements

	Pumps		Compressor systems				Valves	Link
Shutdown action Initiation	Cargo pumps/cargo booster pumps	Spray/ stripping pumps	Vapour return compressors	Fuel gas compressors and system	Reliquefaction plant, including condensate return pumps, if fitted	Gas combustion unit	ESD valves	Signal to barge or regas' unit/shore link***

Emergency push buttons (*see* 20.4.4.2)	✓	✓	✓	*See* Note 2	✓	✓	✓	✓
Fire detection on deck or in compressor house*	✓	✓	✓	✓	✓	✓	✓	✓
High level in storage tank	✓	✓	✓	*See* Notes 1 and 2	*See* Notes 1 and 3	*See* Note 1	*See* Note 4	✓
Signal from barge or regas' unit/shore link	✓	✓	✓	*See* Note 2	*See* Note 3	n/a	✓	n/a
Loss of motive power to ESD valves**	✓	✓	✓	*See* Note 2	*See* Note 3	n/a	✓	✓
Main electric power failure ('blackout')	*See* Note 5	*See* Note 5	*See* Note 5	*See* Note 5	*See* Note 5	*See* Note 5	✓	✓

KEY

* Fusible plugs, electronic point temperature monitoring or area fire detection may be used for this purpose on deck

** Failure of hydraulic, electric or pneumatic power for remotely operated ESD valve actuators

*** Signal need not indicate the event initiating ESD

✓ Functional requirement

n/a Not applicable

NOTES

1. These items of equipment can be omitted from these specific automatic shutdown initiators provided the compressor inlets are protected against cargo liquid ingress.
2. If the fuel gas compressor is used to return cargo vapour to shore, it shall be included in the ESD system only when operating in this mode.
3. If the reliquefaction plant compressors are used for vapour return/shore line clearing, they shall be included in the ESD system only when operating in that mode.
4. A sensor operating independently of the high liquid level alarm shall automatically actuate a shut-off valve in a manner that will both avoid excessive liquid pressure in the loading line and prevent the tank from becoming liquid full. These sensors may be used to close automatically the tank filling valve for the individual tank where the sensors are installed, as an alternative to closing the ESD valve provided at each manifold connection. If this option is adopted, activation of the full ESD system shall be initiated when the high-level sensors in all the tanks to be loaded have been activated.
5. These items of equipment shall be designed not to restart automatically upon recovery of main electric power and without confirmation of safe conditions.

LR 20.4.4.5 The emergency shutdown system associated with the regasification system shall be designed, manufactured and tested in accordance with the principles stated in Pt 11, Ch 5.5.

LR 20.4.4.6 The number and location of additional shutdown positions shall be determined by the type, number, location and position of the regasification plant, sub-systems and equipment.

LR 20.4.5 Process shutdown (PSD) system

LR 20.4.5.1 A process shutdown system (PSD) for the regasification system shall be arranged in accordance with the requirements listed in Section LR 20.6.

LR 20.4.5.2 The activation of the PSD shall stop the supply of LNG to the LNG suction drum, high pressure LNG pumps and gas discharge valve. Where the installation comprises a number of separate regasification systems the PSD may be system-specific as well as initiating a full shutdown. A PSD functional arrangement matrix commensurate with that shown in Table LR 20.4.1 shall be provided.

LR 20.4.5.3 Manual PSD points shall be arranged at each regasification system's control station and at locations as determined by the type, number, location and position of the regasification systems and equipment. The process shutdown points shall be clearly indicated.

LR 20.4.5.4 Process shutdown valves in liquid piping shall close fully under all service conditions within an acceptable duration of actuation. Due regard shall be given in the design of the process shutdown system to avoid the generation of surge pressures within drain pipelines and collect tanks. Information about the closing time of the valves and their operating characteristics shall be available on board and the closing time shall be verifiable and reproducible.

LR 20.4.5.5 The closure time for the shutdown valve referred to in LR 20.5.4 shall be measured from the time of manual or automatic initiation to final closure and is made up of a signal response time and a valve closure time. Valve closure time shall be such as to avoid surge pressure in pipelines.

LR 20.4.6 Depressurisation and blowdown system

LR 20.4.6.1 In accordance with ISO 23251 or equivalent.

LR 20.4.6.2 A depressurisation and blowdown system shall be provided for depressurising high pressures liquid, vapour and gas systems. Each high pressure system may contain; liquid pumps, gas compressors, vessels, heat exchangers and pipework.

LR 20.4.6.3 Where a liquid depressurisation system is provided, adequate provision shall be made in the design and installation for the effects of back pressure after the blowdown valve and the resulting volume of vapour flash gas due to the pressure drop.

LR 20.4.6.4 Manual and automatic activation of the depressurisation system shall be provided.

LR 20.4.6.5 Manual activation shall be possible from each regasification system's control station, at the send-out manifold, and from other locations as determined by the type, number, location and position of the regasification systems and equipment. The depressurisation and blowdown system activation points shall be clearly indicated.

LR 20.4.6.6 Automatic activation shall be part of the emergency shutdown arrangements.

LR 20.4.7 System and pressure vessel protection

LR 20.4.7.1 Each regasification system and associated pressure vessel is to be fitted with a form of secondary protection. This may take the form of pressure relief valves or alternatively an instrument-based system.

LR 20.4.7.2 Pressure relief and venting system

LR 20.4.7.2.1 Each regasification unit shall be provided with safety relief valves and venting arrangements which are to be separate from the venting arrangements serving the LNG storage tanks. High pressure safety relief valves, headers, knock-out pots, collection tanks, drain drums and vent masts shall be located within the cargo deck area.

LR 20.4.7.2.2 High pressure safety relief valves and venting arrangements for liquid and gas shall be provided for each regasification system. The safety relief valve support arrangements shall be suitable to withstand the loads imposed by relief valve opening.

LR 20.4.7.2.3 Where multiple regasification systems are installed, the design of pressure safety relief and venting arrangements shall consider the maximum combined release rate.

LR 20.4.7.2.4 The gaseous phase safety relief valves shall be led to a dedicated high pressure vent mast for the regasification system required by LR 20.4.7.2.1. The high pressure vent mast shall be sized to handle the maximum regasification capacity and to ensure safe dispersal of the gas.

LR 20.4.7.2.5 The liquid phase safety relief valves shall be led to a knock-out pot, collection tank or drain drum having adequate capacity for the maximum LNG inflow anticipated within the design of the regasification unit. The collection vessel shall be fitted with a level switch to stop all high pressure LNG pumps. Any LNG from the collection vessel shall be safely drained back to the LNG storage tanks or be allowed to boil off and vapour to be returned to the barge or offshore unit's vapour header.

LR 20.4.7.2.6 LNG collection vessels shall be fitted with pressure safety relief valves in accordance with Pt 11, Ch 5.

LR 20.4.7.2.7 Pressure safety relief valves and venting arrangements and locations shall comply with Pt 11, Ch 8.

LR 20.4.7.3 Instrument-based system

LR 20.4.7.3.1 Instrument-based systems, in compliance with ISO 10418, may be used for both primary and secondary protection provided it is implemented in accordance with IEC 61511-1.

LR 20.4.8 Fire protection and fire extinction

LR 20.4.8.1 The regasification system shall be protected with both a water spray deluge system plus a dry chemical powder system and a fire detection system. The systems shall meet the requirements of Pt 11, Ch 11.

LR 20.4.8.2 The water spray deluge system and dry chemical powder system installed on board the barge or offshore unit shall be capable of providing coverage for the areas defined in Pt 11, Ch 11 and the regasification system simultaneously.

LR 20.4.8.3 The barge or offshore unit's water spray deluge system shall be designed to cover the regasification equipment, barge or offshore unit-to-ship LNG flexible hoses or loading arms and gas export manifold.

LR 20.4.8.4 Protection from fire and heat shall be provided as necessary for the safe escape of personnel in case of an emergency. Details shall be submitted for appraisal as indicated in LR 20.2.1.1.

LR 20.4.8.5 Fire protection arrangements shall be such as to prevent possible jet fires propagating from the regasification unit

to the adjacent LNG storage tank areas. Proposed arrangements shall be evaluated in the risk based studies in Section LR 20.3.2.

LR 20.4.9 Location and arrangement of equipment

LR 20.4.9.1 The location of the regasification unit and its sub-systems containing LNG and NG shall be considered part of the cargo area. The regasification units and all their associated equipment shall be located as far as is reasonably possible from accommodation spaces.

LR 20.4.9.2 The regasification system machinery may be located on the open deck or in cargo pump and cargo compressor rooms. Arrangements of such spaces shall be in accordance with the requirements of Pt 11, Ch 3.

LR 20.4.9.3 When the regasification units are located on open deck they shall be placed in a sheltered location protected from green water.

LR 20.4.9.4 The location~~s~~ of the system arrangements, including vaporisers, high pressure pumps, suction drums, heaters, liquid pumps and ancillary piping systems, shall be defined and evaluated in the system safety risk assessment, *see* Section LR 20.3.2, and shall be acceptable to LR.

LR 20.4.9.5 The deck plating and sub-structure of the barge or offshore unit shall be protected from possible cryogenic spills associated with the regasification unit and suction drum in way of fittings, fixtures and demountable joints. No protection will be required in locations where the deck and sub-structure material can withstand cryogenic temperatures.

LR 20.5 Piping requirements

LR 20.5.1 General

LR 20.5.1.1 Regasification system piping shall meet the applicable requirements of Ch 5 and Pt 5, Chs 12, 13 and 14.

LR 20.5.1.2 All piping, valves and fittings shall be suitable for the design operating pressures and temperatures and environmental conditions.

LR 20.5.2 Materials

LR 20.5.2.1 All materials used in the piping systems shall be suitable for use with the intended medium, service and ambient conditions, and shall comply with the applicable requirements of Ch 6 and Pt 5, Ch 12.

LR 20.5.3 Piping design

LR 20.5.3.1 Piping between the barge or offshore unit LNG storage system and the regasification system shall be equipped with a manually operated stop valve and a remotely controlled emergency shutdown valve. These valves shall be located as close to the LNG storage tank as practicable. When the regasification unit is located in the forward section of the barge or offshore unit, such isolation shall be as near as possible to the boundary of the forward most LNG storage tank bulkhead and within the cargo area.

LR 20.5.3.2 Dry break quick-release connectors shall be provided for use in an emergency in:
(a) piping between an LNG supply ship and the barge of offshore unit;
(b) send-out gas piping between the barge or offshore unit and receiving terminal.

LR 20.5.3.3 A manually operated shut-off terminal valve shall be provided at the send-out manifold, in addition to any other automatic shut-off valves required, *see* LR20.4.4 and LR20.4.5.

LR 20.5.3.4 The spool piece, reducers, valves and other fittings to which the LNG storage system or the send-out system is directly connected shall be of approved material. They shall be of robust construction, adequately supported and suitable for the stated design conditions and manifold forces. For LNG transfer, attention is drawn to SIGTTO '*Manifold Recommendations for Liquefied Gas Carriers*'.

LR 20.5.3.5 Means of draining, purging, inerting and gas-freeing the pipe lines used for the regasification system shall be provided.

LR 20.5.3.6 Means of mechanical separation shall be provided between the regasification piping system and the barge or offshore unit's inert gas and nitrogen systems.

LR 20.5.3.7 All main isolating valves serving the regasification systems and equipment shall be positioned in a readily accessible location.

LR 20.5.3.8 The fabrication and installation of the piping associated with the regasification plant and sub-systems shall be in accordance with the relevant Sections of these Rules.

LR 20.5.3.9 Provisions shall be incorporated in the design to minimise the number of flanged connections. In order to protect

personnel from cryogenic burns and prevent the barge or offshore unit's structure or other carbon steel structures on deck from being exposed to brittle fracture due to LNG pressure jet, consideration shall be given to the fitting of spray shield arrangements to any flanged connection of piping containing LNG at a pressure above 10 bar g.

LR 20.5.3.10 Where applicable, all LNG pipework serving the regasification system shall be suitably thermally insulated and covered with an efficient vapour barrier.

LR 20.5.3.11 Both low and high pressure LNG supply pipework serving the regasification systems is to be subject to a stress analysis, taking into account ship motions and deflections.

LR 20.5.4 Piping system testing and non-destructive examination

LR 20.5.4.1 Testing and non-destructive examination of the regasification unit's LNG supply and gas discharge piping systems shall comply with the relevant requirements of Ch 5 and Pt 5, Ch 12.

LR 20.5.4.2 All piping systems shall be subjected to a hydrostatic test in accordance with Table LR 20.5.1. When piping systems or parts of systems are completely manufactured and equipped with all fittings, the hydrostatic test may be conducted prior to installation on board the barge or offshore unit. Joints welded on board shall be hydrostatically tested in accordance with Table LR 20.5.1. Where water cannot be tolerated or the piping cannot be dried prior to putting the system into service, proposals for alternative testing fluids or testing means shall be submitted for special consideration by the Surveyor.

Table LR 20.5.1 Strength and leak pressure testing

System	Test pressure, bar g	
	Strength test	Leakage test
LNG and NG below 40 bar g LNG and NG at and above 40 bar g.	1,5 *p* 1,25 *p*	*See* LR 20.5.4.3 *See* LR 20.5.4.3

NOTE
p is the design pressure which is the maximum permissible pressure within the system (or part system) in operation or at rest.

LR 20.5.4.3 After assembly on board, all cargo and process piping shall be subjected to a leak test using air, halides or other suitable medium to a pressure dependent on the leak detection method applied.

LR 20.5.4.4 All piping systems including valves, fittings and associated equipment for handling cargo or vapours shall be tested under normal operating conditions prior to the first regasification operation.

LR 20.6 Instrumentation, control, alarm and monitoring

LR 20.6.1 Functional objectives

LR 20.6.1.1 The regasification plant and sub-systems shall be provided with appropriate controls for safe operation of the regasification system with adequate alerts and safeguards.

LR 20.6.2 Performance requirements

LR 20.6.2.1 Instrumentation, control, alarm and monitoring systems shall comply with the requirements of this Section and Pt 6.

LR 20.6.2.2 The system shall be provided with automatic and/or remote controls to ensure the system operates within its design parameters.

LR 20.6.2.3 A system for monitoring and indicating alerts shall be provided.

LR 20.6.2.4 The system shall be provided with safeguards such as a high pressure trip, which will operate to prevent a hazard occurring or to reduce an existing hazard to persons, machinery, the barge or offshore unit or the environment.

LR 20.6.2.5 Locations at which the regasification system is controlled shall be provided with a means of communication with the gas-receiving terminal.

LR 20.6.2.6 The regasification system shall be provided with control, monitoring, alert and safety systems that will maintain the system throughout all normal and reasonably foreseeable abnormal conditions.

LR 20.6.2.7 The system shall be provided with the alarms and shutdowns as identified by the system designer or equipment manufacturer. In the absence of such guidance, the alarms and shutdowns indicated in these Rules may be used.

LR 20.6.3 Control station

LR 20.6.3.1 A control station for the regasification system and barge or offshore unit-to-ship operations shall be arranged within a non-hazardous area. Emergency procedures, as defined in Section LR 20.3, concerning regasification and barge or offshore unit-to-ship transfer operations shall be capable of being performed from this station.

LR 20.6.4 Communications

LR 20.6.4.1 At least two means of communication shall be provided between the control station and the receiving terminal; one of these systems shall be independent of the main electrical supply.

LR 20.6.4.2 Internal communication cables shall comply with the applicable requirements of these Rules.

LR 20.6.4.3 The cable installation shall provide adequate protection against mechanical damage and electromagnetic interference.

LR 20.6.4.4 Components shall be located with appropriate segregation such that the risk of mechanical damage or electromagnetic interference resulting in the loss of both active and stand-by components is minimised. Duplicated communication links and equipment shall be routed to give as much physical separation as is practicable.

LR 20.6.5 Equipment and systems – Alarms, shutdowns and safeguards

LR 20.6.5.1 Suitable interlocks shall be provided to prevent start-up of the regasification system under conditions which could hazard the system or its equipment and components.

LR 20.6.5.2 The system designer or equipment manufacturer shall identify the required alarms, shutdowns and safeguards for the design of vaporiser. The minimum shutdown requirements are indicated in Table 20.5.1.

LR 20.6.5.3 The system designer or equipment manufacturer shall identify required alarms, shutdowns and safeguards for the suction drum. The minimum shutdowns requirements are indicated in Table 20.5.2.

LR 20.6.5.4 The control and monitoring arrangements shall be appropriate to enable the system to be controlled within the design parameters specified by the system designer or equipment manufacturer.

Table LR 20.5.1 Alarms, shutdowns and safeguards for vaporisers

Item	Alarm	Note
Gas discharge temperature	Very Low	Automatic shutdown
Sea-water (or heating medium) supply pressure	Very Low	Automatic shutdown
Indication of supply gas pressure to burner (SCV type)	Very Low	Automatic shutdown
Flame failure (SCV type)	Failure	Automatic shutdown
Indication of sump water level (SCV type)	Very Low	Automatic shutdown
Combustion air pressure (SCV type)	Low	Automatic shutdown
	High	Automatic shutdown
Flue gas temperature (SCV type)	High	Automatic shutdown
Gas leak detected		ESD operation (programmed)

NOTES
1. SCV type means submerged combustion vaporiser type.
2. Any additional alarms and shutdowns identified during the Risk Assessment required in Section LR 20.3 are also to be provided.
3. The Table contains the minimum list of alarms and shutdowns for

a regasification plant; additional alarms and shutdowns may be necessary as determined through risk-mitigating activities in response to a completed Risk Assessment as required by Section LR 20.3.
4. If certain alarms and shutdowns are not applicable for the regasification system, sufficient evidence shall be produced to support the claim and shall form part of the Risk Assessment required by Section LR 20.3.

Table LR 20.5.2 Alarms, shutdowns and safeguards for suction drums

Item	Alarm	Note
Suction drum pressure	Low	Automatic shutdown
Suction drum level	Very low	Automatic shutdown
Suction drum level	Very high	Automatic shutdown

NOTES
1. Any additional alarms and shutdowns identified during the Risk Assessment required by Section LR 20.3 are also to be provided.
2. The Table contains the minimum list of alarms and shutdowns for a regasification plant; additional alarms and shutdowns may be necessary, as determined through risk-mitigating activities in response to a completed Risk Assessment as required by Section LR 20.3.
3. If certain alarms and shutdowns are not applicable for the regasification system, sufficient evidence shall be produced and is to form part of the Risk Assessment required by Section LR 20.3.

LR 20.7 Electrical installation

LR 20.7.1 Functional objectives

LR 20.7.1.1 The electrical installation of a regasification system shall be designed, installed and maintained such that it does not represent an ignition hazard or introduce any foreseeable hazards into the normal operation of the barge or offshore unit.

LR 20.7.2 Performance requirements

LR 20.7.2.1 The installations shall meet with the requirements of Pt 6, Ch 2, or an alternative relevant National or International Standard acceptable to LR, as applicable.

LR 20.7.2.2 All electrical equipment shall be suitably protected against damage to itself under fault conditions, provide adequate protection to prevent damage to other process equipment connected to the system and to prevent injury to personnel.

LR 20.7.3 System design, construction and installation

LR 20.7.3.1 The electrical power for the regasification system shall be provided by an individual dedicated circuit from the main switchboard.

LR 20.7.3.2 Where the ✠ **Lloyd's RGP+** Notation is assigned, the system shall be provided by two individual circuits separated in the main switchboard or section board and throughout its length and without the use of common feeders. Where a stand-by unit is provided, it shall be supplied from a separate section of the main switchboard to ensure a single point equipment failure does not render both systems inoperable.

LR 20.7.3.3 Electrical equipment for the regasification system shall be suitable for use in the environmental conditions envisaged during regasification mode. It is also to be appropriately installed to prevent any adverse effects due to environmental conditions encountered when not in use.

LR 20.7.4 Hazardous zones and spaces

LR 20.7.4.1 The classification of hazardous zones associated with the regasification plant shall be carried out in accordance with IEC 60079-10-1 or an alternative relevant National or International Standard acceptable to LR.

LR 20.7.4.2 The hazardous zones plan shall identify areas where the release of flammable gases and vapours may be present due to the regasification system during normal working operation and reasonably foreseeable abnormal conditions, as identified during the Risk Assessments required by Section LR 20.3.

LR 20.7.5 Certified safe type equipment

LR 20.7.5.1 Selection of electrical equipment within the hazardous zones shall be in accordance with Pt 6, Ch 2.

LR 20.8 Regasification testing and trials

LR 20.8.1 Testing and trials prior to commissioning

LR 20.8.1.1 During construction or conversion of the barge or offshore unit, the following additional tests and trials for the regasification system shall be carried out:

- Pressure and leak test of LNG and NG piping.
- Suction drum leak test.
- Safety valves setting.
- Function tests of fire safety systems, emergency shutdown system, process shutdown system, gas detection system, depressurising and blowdown system.
- Function tests of control, monitoring, alert and safety systems.
- Regasification heating pumps function tests.
- Verification of the requirements derived from the Risk Analysis as required by Section LR 20.3.
- Verify the equipment fails safe when subjected to a simulated failure of systems and equipment.

LR 20.8.2 Commissioning regasification trials

LR 20.8.2.1 The regasification trials program shall be prepared and submitted for approval. The regasification trial program shall include technical and operational information relevant to such testing.

LR 20.8.2.2 Preliminary regasification trials shall consist of a running test of the regasification system with LNG low flow for the function test and shall be carried out after gas trials and before delivery.

LR 20.8.2.3 The full capacity test of the regasification plant shall be carried out at an operational site.

LR 20.8.2.4 The test and measurements shall be carried according to these Rules, manufacturer's standards and industry best practice.

LR 20.8.2.5 After completion of the regasification trials, a report quantifying that the trials programme has been satisfactorily completed, shall be prepared and submitted. A copy of the report shall be retained on board the barge or offshore unit.

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